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ABSTRACT

This publication provides abstracts of papers presented at the 50th annual meeting of the National Association for Research in Science Teaching held in Cincinnati, Ohio March 22-24, 1977. The entries represent a wide range of topics in the field of science education. Topics include instruction, teacher education, learning, enrollments, concept development, scientific literacy, teacher behavior, and curriculum. (RH)

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NATIONAL ASSOCIATION
FOR RESEARCH IN SCIENCE TEACHING
50TH ANNUAL MEETING
ABSTRACTS OF PRESENTED PAPERS

Netherland Hilton
Cincinnati, Ohio
March 22-24, 1977

ERIC Center for Science, Mathematics,
and Environmental Education
College of Education
The Ohio State University
1200 Chambers Road, Third Floor
Columbus, Ohio 43212

SE 022 328

PREFACE

The ERIC Information Analysis Center for Science, Mathematics, and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Cincinnati, Ohio, March 22-24, 1977.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. Roger G. Olstad and the NARST Program Committee who obtained the abstracts and organized the program, and to Dr. Patricia Blosser for extensive assistance in preparing the abstracts.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education and other publications of the ERIC system.

March, 1977

Stanley L. Helgeson
Editor

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GENERAL SESSION I

Presiding: O. Roger Anderson, Columbia University, New York, New York 10027.

Speaker: E. Paul Torrence, University of Georgia, Athens, Georgia 30602.

"Science Teaching and Students' Images of the Future:

Some Suggested Implications"

CONCURRENT SESSIONS I

Session IA - Learning Theory: Piaget

Presiding: Richard D. Kellough, California State University, Sacramento, California 95819.

1. "Content Specific Cognitive Growth and General Cognitive Growth and its Relation to the Theories of David Ausubel and Jean Piaget." Gerald S. Friedman, Cornell University, Ithaca, New York 14850.

2. "The Relationship Between Cognitive Styles and One Type of Logical Reasoning." Patricia M. Heller, University of Michigan, Ann Arbor, Michigan 48109.

3. "A Comparison of Student Preferences and Actual Performance in Problem Solving Tasks within a Piagetian Setting." David L. Dunlop, University of Pittsburgh at Johnstown, Johnstown, Pennsylvania 15905 and Frank Fazio, Indiana University of Pennsylvania, Indiana, Pennsylvania 15701.

4. "The Effect of Instructional Mode on School Achievement of Concrete and Formal Operational Students." John J. Rastovac, California State University, Long Beach, California 90801.

5. "A Study of the Relationship Between Cognitive Development and Achievement in College Physics: A Statistical Search for a Theoretical Framework." Russel M. Agne, H. Daniel Cohen, and Donald F. Hillman, University of Vermont, Burlington, Vermont 05401.

CONTENT SPECIFIC COGNITIVE GROWTH AND GENERAL COGNITIVE GROWTH AND ITS RELATION TO THE THEORIES OF DAVID AUSUBEL AND JEAN PIAGET

Gerald S. Friedman
Cornell University
Ithaca, New York 14850

In two of Piaget's earliest works, dealing with the child's understanding of physical events, he found the child's beliefs passing through several stages. These stages, divided into three major categories and several sub-categories, affect the totality of the child's thought concerning physical events. Piaget has also indicated that the states determine learning, the child being more apt to modify his cognitive structure when he controls his own learning and is allowed to choose his learning material from a wide variety that is provided. David Ausubel has indicated that conceptual material can be meaningfully learned if it is related in a non-arbitrary and substantive way to what the learner already knows. If this is so, then the stage of cognition would not be a relatively unitary level but would vary with the meaningful learning in each concept area. This study attempted to test these contrasting ideas.

Two groups of first grade students were selected. The instructed group had experienced the Audio-tutorial Elementary Science Project (ATESP) level-one lessons. This is a thirty lesson, cassette-instructed series that deals with science concepts, with each lesson having a host of materials that the students are directed to manipulate. The series was developed at Cornell University, under the directorship of Professor Joseph Novak. Four months after the end of the science lessons, both groups experienced a mini-lesson, of about twenty minutes duration, dealing with the nature of, and the consequences of, heating solids and liquids. The students in each group were then individually tested, using a brief paper and pencil test and a semi-structured (clinical) interview dealing with two types of questions: those that could be answered using concepts learned in the science lessons and those that could not be answered using concepts in the science lessons.

The responses were classified in two ways. First, they were classified according to the adequacy of the response, from a scientific viewpoint. Next, each response was classified according to the stage of the conception of physical causality exhibited. A comparison between the instructed and uninstructed groups was carried out concerning the mean response for each question. A "variability score" was developed for the total responses given by each subject. This score indicated the within-subject variability in the responses.

The instructed group exhibited a higher stage (.025, $p < .01$) when the questions related to their conceptual learning than did the uninstructed group. There was no difference in the level of their responses (.90, $p < .85$) when the questions did not relate to instruction. The variances in the variability scores were different ($p < .01$), so the variability scores of the subjects in the instructed group who responded correctly to one or more of the questions (which indicated meaningful learning) were compared to the variability scores of the uninstructed group. These scores were found to be significantly different (.025, $p < .01$). These results support Ausubel's theory. Meaningful learning, even for very young students, can occur in a structured situation. This type of learning will raise the level of thought in content specific areas, while leaving the level relatively unchanged in those areas that do not relate to the instruction.

THE RELATIONSHIP BETWEEN COGNITIVE STYLES AND ONE TYPE OF LOGICAL REASONING

Patricia M. Heller
University of Michigan
Ann Arbor, Michigan 48109

Recent research indicates that the majority of college students do not operate at the formal operational stage of cognitive development. These findings imply that many students are unable to follow the abstract, logical presentations which characterize traditional college teaching. Little is presently known, however, about specific factors which contribute to the transition from concrete to formal cognitive functioning. Some investigators suggest that an individual's cognitive styles may influence the attainment of formal operational thought.

The purpose of this study was to investigate the relationship between two cognitive styles (conceptual tempo and field independence) and reasoning patterns on six logically equivalent, written problems. Performance on any task can be influenced by a variety of variables, including the syntactical structure of the problem, familiarity with the content, the number of elements in the problem, the order of presentation of relevant information, and embeddedness in irrelevant information. To control for some of these variables, the six problems were designed to vary in content and in complexity.

One hundred and twenty education majors participated in this study. Cognitive styles were assessed individually using the Matching Familiar Figures Test (Kagan et al., 1964) and the Embedded Figures Test (Witkin et al., 1962). The six written problems were administered to the students in small groups. The problems were designed using the Islands Puzzle (Karplus and Karplus, 1970) as a prototype. Each problem requires the student to first respond "yes," or "no," or "can't tell," and then to carefully explain how he arrived at his answer. A type of hypothetico-deductive reasoning employed frequently in the interpretation of data and in science inquiry (denying the consequent reasoning) could be used to solve each problem.

The data were analyzed using multiple regression analysis to determine partial correlations between the two cognitive styles, Scholastic Aptitude Test scores, and the logical quality of responses to the six problems. Since logical quality cannot be operationally defined, 80 judges rated a selection of typical responses for each problem. In addition, the judges rated the relative complexity of the six puzzles using the number of elements and embeddedness of relevant information as the criteria. These ratings were analyzed by the Method of Successive Intervals to obtain relative scale values for student responses, by which the whole data set was scored.

A COMPARISON OF STUDENT PREFERENCES AND ACTUAL PERFORMANCE IN PROBLEM SOLVING TASKS WITHIN A PIAGETIAN SETTING

David L. Dunlop
University of Pittsburgh at Johnstown
Johnstown, Pennsylvania 15905

and

Frank Fazio
Indiana University of Pennsylvania
Indiana, Pennsylvania 15701

Research designed to study the relationship between abstract preferences in problem solving tasks and abstract ability (formal thought) has been reported in the literature; however, these studies have used paper and pencil tests to establish a student's abstract ability and abstract preferences. The purpose of this study was to take the next logical step and examine a student's actual performance on several problem solving tasks. From these performances the student's abstract ability and preferences were directly established within a "real world" setting. Specifically, this study investigated, within a Piagetian setting, the relationship between an individual's stated preference and his or her ability to implement this preference and successfully solve a related science task.

One hundred twenty-five science students were randomly selected and asked to complete an abstract preference survey. This survey required the students to read eighteen problem solving tasks and to select, for each task, the method which they would prefer to use *if* they were to actually solve the problem. Later, three of the tasks from the preference survey were individually administered to the students, and they were then asked to solve the tasks. Observers recorded the method(s) actually used by each student as well as the degree of success. Comparisons between a student's preferred problem solving method and his actual problem solving method could then be made for several different groups of students.

The randomly selected subjects were from a Pennsylvania high school and a college. Chi-Square analysis was used to examine the consistency between a student's stated preference for solving a problem and his actual choice of a method to solve the problem. T-tests and analysis of variance techniques were used to compare the problem solving ability of the different groups of students.

There were significant differences in the cognitive abilities of the formal and concrete groups of students; however, there was no significant difference in the abstract preference scores of the two groups. Further, the "consistent scores" (a measure of the degree to which a student actually attempted to solve a problem in comparison with a previously stated preference for solving that particular problem) for the two groups were not significantly different. It was found however, that although several concrete operational students preferred to solve the problems in an abstract manner, they were generally unsuccessful in their efforts. Of the students who preferred a concrete approach, it was found that the concrete operational students were almost as successful in solving the problem as were the formal operational students.

An understanding of the relationship between a student's problem solving preference and his ability to successfully (or unsuccessfully) implement that preference could be advantageous to the classroom science teacher. This study provided data which suggest that children who are capable of functioning only at the concrete level of operations frequently prefer to attempt to solve problems in a manner for which they are not capable of success. Further, formal operational children frequently prefer to solve problems in a concrete manner. This is true because they probably see the concrete solution as more efficient.

THE EFFECT OF INSTRUCTIONAL MODE ON SCHOOL ACHIEVEMENT OF CONCRETE AND FORMAL OPERATIONAL STUDENTS

John J. Rastovac
California State University
Long Beach, California 90801

Previous studies on the attained level of cognitive development have indicated that approximately 50 percent of high school students have not reached the formal operational level. However, studies with samples of disadvantaged students have found that an initial lag in the development of concrete operations may persist and increase with age. These latter populations may be described as being stabilized at the concrete operational level. The purpose of this study was to compare the effectiveness of audio-tutorial and teacher-directed inquiry instructional modes on school achievement for students from such dissimilar populations.

The samples consisted of subjects enrolled in introductory biology classes in an inner city (N = 41) and a rural (N = 115) high school. The instructional treatments were randomly assigned to the intact classes, and each group covered identical units that incorporated written study guides with behavioral objectives and concrete experiences. A summative exam (dependent variable) was administered at the end of the experimental period.

Ten Piagetian styled tasks, individually administered, determined the S's operational level. Analysis of data on operational level and S's age confirmed the dissimilarity of the samples. The inner city S's were at a significantly lower operational level while significantly older than the rural S's.

S's scores on the 32 item summative test (KR 20 = 0.71 and 0.78 for inner city and rural samples respectively) were analyzed for differences in mean achievement due to treatments and level of cognitive development. The pattern of results was as follows. While within school comparisons (ANOVA) indicated no significant treatment effect, there was a significant difference in mean achievement ($p < .01$) in favor of the formal operational S's. Significant differences ($p < .01$) were found in all possible between school comparisons except for those comparing inner city concrete operational S's in the AT group with rural concrete operational S's in either treatment.

Previous research on the AT format has supported its effectiveness in promoting increased levels of school achievement, particularly for S's characterized in low ability groups by standardized measures of achievement. The results of this research indicated that similar improvements may result from utilizing the AT format with S's stabilized at the concrete operational level. If stabilization at a particular stage of development impedes cognitive

growth through instructional intervention, then the goal of providing a meaningful instructional alternative in terms of increased levels of school achievement should not be overlooked. In this regard AT may provide a viable alternative approach.

A STUDY OF THE RELATIONSHIP BETWEEN COGNITIVE DEVELOPMENT AND ACHIEVEMENT IN COLLEGE PHYSICS: A STATISTICAL SEARCH FOR A THEORETICAL FRAMEWORK*

Russel M. Agne
H. Daniel Cohen
Donald F. Hillman
University of Vermont
Burlington, Vermont 05401

This research sought to measure the relative importance of intrinsic ability and motivation in determining success in introductory college physics courses and to develop a theoretical framework which would enable one to predict those changes in curricula and instructional procedures necessary to improve student success in physics.

At the root of our inquiry was the desire to understand, in a fundamental way, why some students absorb physics at a high rate while others, even many of obvious intelligence, do not. Does this situation occur because the unsuccessful students are not sufficiently motivated and the material is not presented in an interesting enough manner? Is it because they lack some intrinsic ability or talent? Or, is it some other factor or combination of factors? Without answers to these basic questions, one cannot expect to intelligently design introductory physics curricula, to appropriately advise students, or to understand the success of some teaching techniques and the lack of success of others.

This study represented a large scale investigation of the differential predictive validity of cognitive measures on success in college physics courses. The relevance of Piaget's development levels to academic success was an important component of the design.

One hundred ninety-five students from elementary physics courses at The University of Vermont were randomly chosen to participate in the study. Subjects took a battery of tests, including at least one Piagetian test, the Raven Progressive Matrices, the Strong Interest Inventory, the Watson-Glaser Critical Thinking Appraisal, the Embedded Figures Test, the Remote Associates Test. In all, more than 30 variables were investigated.

Subjects were drawn from four levels of elementary physics over a period of two years. Two levels of courses were geared for non-natural science majors (one primarily for nursing and forestry students; the other primarily for physical therapy and medical technology students) and were intended to be terminal courses in the subject. One was aimed primarily at biology (including pre-medical and pre-dental students), chemistry, and mathematics majors. The last was designed for physics majors and engineering students.

Statistical analysis by computer was conducted using the Datatext package. A general cognitive factor represented by either the "Shadows" or "Chemicals" Piaget task was obtained which correlated significantly with physics course, but lacked significant correlation with overall performance in most sections as measured by final course grade. SAT mathematics scores were highly correlated with final grade across sections. A positive attitude toward physics was significantly correlated with formal operational level thinking. Males scored significantly higher on Piagetian levels than did females, and significant interactions were found between attitude and sex on the Piagetian tests. Further, the higher the cognitive level as determined by Piagetian tests, the more positive the attitude toward physics, and conversely, the lower the cognitive level the more negative the attitude toward physics.

*Research was made possible by a grant from the Exxon Education Foundation.

CONCURRENT SESSIONS I

Session IB - Perceptions

Presiding: Mitchell E. Batoff, Jersey City College, Jersey City, New Jersey 07305.

1. "A Possible Explanation of Declining Test Scores or Learning Less Science But Enjoying It More." Wayne W. Welch, University of Minnesota, Minneapolis, Minnesota 55455.

2. "Changes in Curiosity Behavior From Childhood to Adolescence." Rita W. Peterson, California State University, Hayward, California 94542.

3. "Perceptions of Scientific Literacy." Lawrence L. Gabel, The Ohio State University, Columbus, Ohio 43210.

4. "Superstitions Among Ugandan Adolescents: Their Possible Scientific Explanations and Relation to the Science Curriculum." Catherine D. Namuddu, Columbia University, New York, New York 10027.

5. "A Compendium of Values Clarification Research in Environmental Education at Southern Illinois University-Carbondale - Kindergarten through Middle School." Audrey N. Tomera, Southern Illinois University, Carbondale, Illinois 62901.

A POSSIBLE EXPLANATION OF DECLINING TEST SCORES

OR

LEARNING LESS SCIENCE BUT ENJOYING IT MORE

Wayne W. Welch
University of Minnesota
Minneapolis, Minnesota 55455

Declining test scores in science, and other subjects, have been of concern in recent months to teachers, science educators, and the federal government. Several explanations have been proposed including (1) invalid tests, (2) failure of schools to do their job properly, (3) out of school influences, (4) less time spent on science, and (5) reduction in intelligence related to genetic factors and increasing family size. In this paper, evidence is presented which suggests that while achievement scores in science have, indeed, dropped, there has been a concomitant increase in the affective outcomes of schooling. This finding indicates a shift in schooling emphasis as a possible explanation of the test score decline.

Data gathered from 350 science classes in 1972 and again in 1976 were used in this study. Scores were obtained from 8000 students in two cognitive measures; the Welch Science Process Inventory and a test of National Assessment items, the Test of Achievement in Science. Simultaneously, scores were obtained on two affective measures; the Science Attitude Inventory and the Learning Environmental Inventory - Satisfaction.

Statistically significant ($p < .05$) declines were noted on the achievement test and the process inventory, yet significant gains were observed on measures of class satisfaction and science attitude.

An explanation of the findings is considered growing out of the disenchantment of students toward schooling in the late 60's and early 70's. Perhaps teachers feel a need to make school a more satisfying experience with increased emphasis on games, science fiction reading, laboratory exercises, fewer tests, etc., while diminishing those activities associated with traditional content learning: lecture, problem assignments, testing, and workbooks. Increased emphasis on affective outcomes could result in reduced emphasis on traditional cognitive outcomes, given there is a fixed amount of time devoted to science each week.

CHANGES IN CURIOSITY BEHAVIOR FROM CHILDHOOD TO ADOLESCENCE

Rita W. Peterson
California State University
Hayward, California 94542

The human potential to acquire new insights and to create new ideas derives impetus from a behavior known as curiosity. Yet relatively little is known about this form of self-initiated learning which is so important to science and science education. For example, differences found between racial-ethnic groups in the amount and form of curiosity responses to novel objects are as yet unexplained. Children who ask the most questions are often rated highest in curiosity by their teachers, but are least likely to explore novel objects in their environment through sensory motor responses. Black elementary school children exhibit significantly more sensory motor curiosity than do their white peers.

Also perplexing is the finding that an adult's presence has a differential effect on the amount and form of curiosity behavior children express, depending upon the child's age and racial-ethnic identity. A white adult's presence has an inhibiting effect on the amount of curiosity expressed by older children (11-12 years) and by children whose racial-ethnic identity differs from that of the adult present.

The purpose of this research was to look for changes in curiosity behavior over time from childhood to adolescence, by conducting a follow-up study of a single group of pupils whose curiosity behavior was filmed six years ago.

The sample included 32 pupils from the Berkeley public schools who ranged in age from 6-12 years in 1970 and from 12-18 years in 1976. Due to attrition resulting from geographic dispersal, it was impossible to attain equal numbers representing age, sex, and racial-ethnic groups as the original sample (N = 120) had.

For each pupil, two sequences of videotape showing curiosity behavior on two separate occasions taken six years apart were analyzed for changes in amount and form of curiosity expressed. Curiosity behavior was recorded by a hidden camera as pupils spent 10 minutes (5 minutes alone; 5 minutes with an adult present) in a waiting room filled with curiosity-arousing objects. Pupils and parents viewed tapes at the conclusion of the study.

The amount of curiosity expressed through sensory motor responses did not decline from childhood through adolescence but remained constant. Pupils' average response level in 1970 was 2.20, where Level 1.00 = Approaches novel objects; Level 2.00 = Manipulates...; and Level 3.00 = Reorganizes.... In 1976 the average response level was identical: 2.20. Small shifts which

were observed within the sample were compensatory (e.g., among 12th graders, 5 scores increased by 0.50 average while 6 scores decreased by 0.49 average). As predicted, curiosity behavior decreased in the presence of an adult: 2.07. The amount of time spent exploring novel science books and magazines rather than non-verbal materials increased with age but did not predominate.

The results suggest that greater opportunities to explore need to be provided throughout public school (K-12) if the capacity for curiosity--especially sensory motor curiosity--of children and adolescents is to be fulfilled. Moreover, this study demonstrates the need for a longitudinal study of sufficient scope that differences between age, sex, and racial-ethnic groups may provide information necessary to design instructional settings which take advantage of this natural curiosity.

PERCEPTIONS OF SCIENTIFIC LITERACY

Lawrence L. Gabel
The Ohio State University
Columbus, Ohio 43210

One purpose for teaching science is to provide an aspect of an individual's general education which will promote effective citizenship. This has been described as educating for a scientifically literate citizenry.

This study sought to infer dimensions of scientific literacy with regard to a theoretical definition for a group of science oriented persons, for a group of nonscience oriented persons, and for the two groups combined. Comparisons of the strength of agreement of the two orientation groups, and of subgroups of the two groups, with the inferred dimensions were made. Relationships between the inferred dimensions and the predictor variables (a) educational level, (b) amount of science education, (c) educational level of parents, (d) age, and (e) sex were investigated.

A theoretical definition of scientific literacy was developed and used to develop a 45 statement Q-set. A structured Q-set represents aspects of a theory in that the Q-items are operational descriptions of the various facets of the theory. An information sheet was developed to collect biographical data. Both instruments were piloted and refined until they were at an eighth grade reading level. Pearson's r was used to calculate intercorrelation coefficients after the Q-set was sorted in a test-retest situation; the average coefficient was 0.49.

Persons were randomly selected and categorized into subgroups of the two orientations. That is, the science oriented group contained 37 university pure, 38 university applied, and 100 public science persons. The nonscience oriented group contained 75 university and 100 public nonscience persons.

The Q-set, the information sheet, and ancillary materials were mailed without prior consent to the selected persons. They were asked to sort the Q-set in terms of "What should be expected of most high school graduates with regard to science?" A forced sort (five cards per nine piles) was required representing a continuum from least to most important. A 60 percent return was achieved; statistical tests indicated that the returns represented the subgroups as sampled originally.

Descriptive statistics, correlations, factor analysis, analysis of variance, and regression analysis were used to analyze the data and/or test the null hypotheses. Seven inferred dimensions of scientific literacy were developed.

I. Scientific Inquiry - producing new knowledge through a synthesizing activity.

II. Maintaining Current Awareness - valuing people keeping abreast of new developments in science and technology.

III. Valuing Methods of Science - valuing methods which scientists use in their work.

IV. Personal Application of Science - applying scientific knowledge and methods of science in daily lives.

V. Distinguishing Between Science and Technology - making the distinction in terms of goals and results, also understanding how science and technology affect each other.

VI. Utilizing Factual Knowledge - knowing and using factual knowledge about nature.

VII. Mutual Involvement of Science and Society - science providing mankind with new capabilities, also society providing supportive conditions for science.

Several additional generalizations were developed. These were summarized by three major generalizations.

I. Membership in subgroups was more related to respondents' perceptions of scientific literacy than was membership in the science or the nonscience oriented groups.

II. Respondents' individual characteristics (e.g., age, sex, educational level) were related to their perceptions of scientific literacy.

III. Science courses taken by respondents were related to their perceptions of scientific literacy.

The theoretical definition of scientific literacy which was developed for this study can serve as a valid, comprehensive, and functional definition for the present time. The theoretical definition, the inferred dimensions of scientific literacy, and the various findings can:

1. faciliate communication in reference to the educational goal of developing scientifically literate citizens;

2. provide a basis for developing science education programs which will enable persons to attain appropriate levels of scientific literacy; and

3. provide a basis for developing an instrument to assess achievement on the identified dimensions of scientific literacy.

SUPERSTITIONS AMONG UGANDAN ADOLESCENTS: THEIR POSSIBLE SCIENTIFIC EXPLANATIONS AND RELATION TO THE SCIENCE CURRICULUM

Catherine D. Namuddu
Columbia University
New York City, New York 10027

The purpose of this study was to identify the nature and determine the incidence of superstitions among schooling Ugandan adolescents, and to suggest experiences that may assist the adolescents in developing a rational approach to learning.

Solicitation of superstitions from adolescents was part of lessons with teachers initially citing examples of common superstitions. From urban and rural schools, 133 adolescents wrote down, in the presence of the investigator, statements similar to those cited by their teachers. We obtained 513 superstitions. This list was discussed with four elders to ascertain the meanings and traditional origin of the superstitions.

The 513 superstitions were classified under 10 categories; six being based on scientific principles, and four representing philosophical interpretations of various issues of being. The same list was given to four graduate students at Teachers College, who reclassified it according to the 10 categories. Their classifications provided a check on the investigator's scheme.

Two hundred of the 513 superstitions were selected, with the assistance of a higher school graduate, on the basis of their relationship to scientific concepts, and on their amenability to translation into English. These statements, listed alongside five categories: 1) Very Important; 2) Important; 3) Fair; 4) Doubtful; and 5) Not Important; were categorized by eight science teachers, who indicated the degree to which belief in a statement by an adolescent would affect his understanding of its related scientific ideas.

The 41 statements marked 1, and the 59 marked 2, and seven nontraditional superstitions, constituted a questionnaire which four of the teachers, who had categorized the superstitions, evaluated for simplicity, accuracy and completeness.

The incidence of the 107 superstitions among 303 adolescents and 73 university students was determined from their responses to the questionnaire inquiring whether they had heard of, believed in, and were influenced by the ideas expressed in the statements.

Responses to the nontraditional superstitions would indicate respondents' actual reading of individual statements and any environmental basis for their responses. Responses by the adults

would provide comparison to the adolescents', to determine the effect of age, and extended schooling, location and sex.

The proportions of adolescents and adults responding in each category were computed. Among adolescents, 47.76 percent, 38.81 percent and 37.36 percent indicated they had heard of, believed in, and were influenced by the statements. Among adults, 44.06 percent, 25.15 percent and 24.24 percent indicated they had heard of, believed in, and were influenced by the statements.

Superstitions concerning Conditions of Human and Animal Growth, Health and Medicine, Animal Behavior and Philosophical Understandings, represented the largest number by which both adolescents and adults indicated they were influenced. Age and extended schooling were found to influence superstitious belief.

The combined influence of sex and location on superstitiousness among adolescents was that, although rural females said they had heard of more superstitions than either urban females or rural and urban males, they indicated they were influenced by fewer superstitions than were both urban females and rural and urban males.

A COMPENDIUM OF VALUES CLARIFICATION RESEARCH

IN ENVIRONMENTAL EDUCATION

AT SOUTHERN ILLINOIS UNIVERSITY-CARBONDALE

KINDERGARTEN THROUGH MIDDLE SCHOOL

Audrey N. Tomera
Southern Illinois University
Carbondale, Illinois 62901

Science educators have become largely responsible for the research and instruction in environmental education (Fryman, 1976; Trojcak and Harvey, 1976). Similarly, although there is no total agreement on the substantive structure of environmental education, there appears to be considerable agreement that values clarification is an integral component of the discipline. If one views environmental education in terms of "acquisition and application of human values" (Hungerford and Litherland, 1973), one cannot overlook relationships which may exist between knowledge and values. Breer and Locke (1965) believe that there is a relationship between the knowledge gained from a task experience and the development of beliefs, values and preferences pertaining to the task itself.

A review of the literature concerning the clarification of values relating specifically to environmental education shows very few empirical studies completed in that area. This paper is a synopsis and synthesis of four studies completed at SIU-C from 1973 to 1976 which focused on the relationship of knowledge to values clarification and/or value shifts with respect to environmental problems or issues.

Since four studies were conducted, each differed slightly in design.

1. In the study done by Hungerford (1973), 112 eighth graders were involved in a pre-post-no control design. Each student was interviewed prior to and after a 12 week period of instruction in the skills of conducting research in environmental education (EE) plus an autonomous EE research study of the student's choosing. A phenomenological open-ended questionnaire was used with each student.

2. In a study by Gisaga (1975), 17 fifth graders and 33 eighth graders were interviewed using an open-ended questionnaire in a pre-post-no control design. In this study students first received instruction in the skills of conducting EE research. They were then pretested, engaged in autonomous EE research and finally posttested.

3. In a study by Aird (1974-75), 50 sixth grade students were used in a pre-post, control-experimental research design. The experimental group received a guided discovery treatment related to water, its use, misuse and importance to man. A written opinionnaire method of testing was used with both groups.

4. In a study by Bryant (1976), 40 kindergarten students were involved in a pre-post control group rotation design. Treatment involved instruction in three components of the environment: air, sound, and solid waste. A recorded interview method of data collection was used with the children.

All data were gathered by use of opinionnaires and/or questionnaires in either a verbal or written manner. Questions regarding the knowledge gained, the importance of the environmental issue to man and what actions the students verbalized they would take, were asked. It was assumed that a phenomenological pursuit of the data would result in a relatively accurate communication of students' knowledge and values. In all instances, the researchers acquiesced that values were measured in only a verbal manner. Actual student action was not pursued. Data were further broken down into numerical form by ascertaining how many discrete value positions were communicated on both pre and posttests. Analysis was made on the basis of the numerical breakdown. Interscorer reliability was established in the Bisaga (1975) and Aird (1975) studies.

In all instances, subjects were positively affected by treatment. Instructional units increased awareness of environmental issues and brought about value shifts in subjects. It would seem that knowledge does influence values. Although directionality was not applied to the shifts in values, discrete responses indicated that the subjects verbally stated more action-oriented responses on the posttest than on the pretest as well as more knowledge as to what to do.

Data from the four studies indicate the importance of knowledge of environmental education issues on the value constructs of elementary and middle school students. It would seem that human values can be influenced via learning. These four studies uncover empirical evidence substantiating the importance of the learning process and its influence on value constructs. The four authors recommend that further research be initiated to investigate the implementation of active, overt behavioral patterns in individuals who verbally espouse values concomitant with action modes.

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Session IC - Paper Set: Philosophical Analyses

Presiding: Paul C. Beisenherz, University of New Orleans. New Orleans, Louisiana 70122.

1. "Philosophical Analysis and Science Education Research: Introduction and Recapitulation." Douglas A. Roberts and Brent Kilbourn, The Ontario Institute for Studies in Education, Toronto, Ontario, Canada M5S 1V6.

2. "Analyzing Science Teaching: The Quality of the Intellectual Experience and the Concept of Intellectual Independence." Hugh Munby, Queen's University, Kingston, Ontario, Canada K7L 3N6.

3. "Analyzing Arguments for Objectives in Science Education." Graham W. F. Orpwood, The Ontario Institute for Studies in Education, Toronto, Ontario, Canada M5S 1V6.

4. "Applying Philosophical Analysis to Science Teaching: Strategies for Inservice Work with Teachers." Thomas L. Russell, The Ontario Institute for Studies in Education, Toronto, Ontario, Canada M5S 1V6.

5. "Identifying World Views: Mechanism and Potential Consequences for Science Students." Brent Kilbourn, The Ontario Institute for Studies in Education, Toronto, Ontario, Canada M5S 1V6.

PHILOSOPHICAL ANALYSIS AND SCIENCE EDUCATION RESEARCH:

INTRODUCTION AND RECAPITULATION

Douglas A. Roberts

and

Brent Kilbourn
The Ontario Institute for Studies in Education
Toronto, Ontario, Canada M5S 1V6

This paper is intended to be one of a paper set based on a particular approach to science education research. The approach was described in detail in a presentation at the 1974 NARST meeting, and subsequently in a lengthy published paper complete with six examples.

The import of this present paper is to review briefly the key points about the purpose, outcomes, and modus operandi of the alternative methodology, as an introduction to and advance organizer for a paper set in which new work in this area will be presented.

The alternative research approach uses philosophical analysis (rather than, say, statistical analysis) as its major tool. Thus it incorporates--indeed, it requires--substantial and careful conceptualization before undertaking empirical examination of common science education phenomena such as transcripts of teaching, textbook passages, or arguments presented in favor of particular objectives.

The purpose of this alternative approach is to develop and exploit theoretical perspectives which make obvious provision for the improvement of practice. Any contribution to "theory development" (in the typical natural-sciences and behavioral-sciences paradigms of much science education research) is a secondary consideration. The articulation of this approach, then, shares many features with the revival of interest in phenomenology, hermeneutics, and ethology. That is, the highly abstracted lenses of theory-bent investigation are relinquished in favor of conceptualizations which preserve a more comprehensive set of characteristics of the phenomena themselves.

The outcomes of this alternative approach are systematically developed theoretical perspectives and systematically analyzed phenomena--as opposed to empirical claims aimed at theory development. The approach is based very much on a deliberate choice about the potential of thought for influencing practice.

While there is no methodological recipe for describing the modus operandi of this alternative approach to science education research, it is possible to identify certain argumentative moves which have definite characteristics. (1) The investigator

identifies his own concern with a "grievance" of some sort, closely associated with some issue in everyday science education practice. This might be an issue related to the nature of knowledge, to the application of authority in the classroom, to the status of models in scientific thought, etc. (2) A reflexive search then begins for systematic philosophical treatments of the issue. Ultimately a comprehensive enough theoretical perspective is isolated to permit understanding of the original issues. (3) The theoretical perspective is then translated to the context of science education, through establishment of a "clue structure," or "analytic scheme," by which actual instances of science education phenomena can be examined. The examination gives the investigator an indication of the adequacy of the clue structure for comprehending practice, and usually suggests some refinements.

The approach thus begins in matters of practice, moves to the realm of theory, and subsequently returns to practice once again, comprehensively and informatively. The skill required of the researcher becomes evident in the rigor needed to identify theoretically determined philosophical distinctions in actual instances of practice.

ANALYZING SCIENCE TEACHING: THE QUALITY OF THE INTELLECTUAL EXPERIENCE AND THE CONCEPT OF INTELLECTUAL INDEPENDENCE

Hugh Munby
Queen's University
Kingston, Ontario, Canada K7L 3N6

The approach employed here, and evident in the companion papers comprising the set, is to develop sound theoretical perspectives for understanding specific aspects of science education. The perspective derives from philosophical analysis and, in the case of this paper, provides a conceptual device for examining science teaching itself.

This paper offers a fresh concept for overcoming some of the problems in classroom observation research stated in the following three propositions (which form the rationale for the inquiry):

1. There is a considerable logical gap between available means for describing teaching behavior (using observation schemes), and the larger purposes of education which, presumably, all instances of teaching are collectively attempting to achieve.

2. Classroom observation instruments, which offer descriptions of teaching, have largely neglected the rich and clear descriptions of teaching which emanate from philosophical analysis of the concept of teaching itself.

3. The core of research and discussion on teaching and learning is prediction, yet classroom observation research has tended to focus on empirical predictions which are not directly related to educational goals and objectives, rather than on logical predictions which have the achievement of educational goals and objectives as their target.

It is argued in this paper that the concept "Intellectual Independence" presents a resolution of these difficulties. "Intellectual Independence" is defined thus: An individual can be said to be intellectually independent when he has all the resources necessary for judging the truth of a knowledge claim independently of other people. The research approach of this paper is to derive the concept of "Intellectual Independence" from epistemological considerations, and then to reveal the relationship it has with the concept of teaching and indoctrination.

It is then shown that it is possible to use the features of the concept to establish an observation scheme for analyzing science teaching. Examples of the scheme in use are provided

which demonstrate how science teaching can be described for its epistemological features. In this way, the paper argues that a theoretical perspective out of philosophical analysis yields a plausible and productive way of systematically analyzing science teaching. Using this approach, it is possible to make sound and reliable judgments about the intellectual quality and climate of science teaching and, at the same time, to make logical predictions about the contribution such teaching can make to a youngster's intellectual independence.

ANALYZING ARGUMENTS FOR OBJECTIVES IN SCIENCE EDUCATION

Graham W. F. Orpwood
The Ontario Institute for Studies in Education
Toronto, Ontario, Canada M5S 1V6

This paper describes the development and use of a scheme for probing arguments mounted in defense of instructional objectives in science education, for the purpose of exposing the bases of such arguments. The perspective used in the development of the scheme is derived from a consideration of science curriculum as a practical enterprise, in the Aristotelian sense. Such a perspective sees curriculum action as the product of a choice among alternatives--in this case, among alternative sets of objectives. Sets of objectives that might make up such an array are characteristically accompanied by arguments seeking to persuade teachers to adopt them. These arguments, then, constitute practical advice to teachers concerning what they should do. A deliberate choice among competing sets of objectives is made more difficult by the fact that the arguments are frequently couched in rhetoric that tends to obscure the issues at stake. The function of the scheme described in this paper is, therefore, to expose the bases of prescriptive arguments so that an informed and deliberate choice may be made.

The conceptual foundation of the scheme draws upon Gauthier's analysis of practical reasoning and advice.[1] It is shown that a prescriptive argument must involve premises of two types: the first and major premise embodies a value position--it characterizes some state as being worthwhile or desirable; the second or minor premise is, ideally, a statement of fact concerning the attributes of the situation or context of activity. Thus, part of the analytical scheme is concerned with the identification of these premises and the conclusion of the argument--the objectives themselves.

When this initial level of analysis is carried out, it can often be seen that the "statements of fact" which are identified are not, on closer examination, matters of fact at all--but are themselves the products of choice. Such statements might include, for example, statements about the nature of science (of which there are many). Thus, a second level of analysis must be carried out in which both the existence of such choices and the values implied by them are revealed. Again, it is in the interests of informed and deliberate choice that these embedded values be exposed.

The paper includes examples of the application of the scheme to science curriculum guidelines and to statements encountered in science curriculum project materials currently in use in North America.

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[1]David Gauthier, Practical Reasoning, Oxford: Clarendon Press, 1963.

APPLYING PHILOSOPHICAL ANALYSIS TO SCIENCE TEACHING:

STRATEGIES FOR INSERVICE WORK WITH TEACHERS

Thomas L. Russell
The Ontario Institute for Studies in Education
Toronto, Ontario, Canada M5S 1V6

This study sought to identify and elaborate significant strategic elements in the process of assisting science teachers in the application of philosophical analysis to their teaching, and in the modification of their teaching according to the results of analysis.

There is general agreement that teaching strategies must be considered in the pursuit of specific objectives of science education. A teacher's strategies define the options available to students, including the kinds of activities in which they may engage in the classroom. We have learned that attempts to prescribe detailed strategies for science teachers to use in the pursuit of valued non-recall objectives (such as inquiry and scientific literacy) fail for a variety of reasons, including misunderstanding, lack of requisite skills, lack of support, and simple reluctance to relinquish personal autonomy.

Derivation of theoretical perspectives by which science teaching may be analyzed offers considerable promise as an incisive and constructive technique for the analysis of teaching and the development of alternative teaching practices. It is clear that researchers can apply philosophical analysis to science teaching. Quite predictably, however, large numbers of science teachers have not plunged into such fields as epistemology seeking ways to examine and modify their teaching. There is an obvious and necessary gap between a research method and the day-to-day deliberations of the practicing science teacher. This study examines activities intended to bridge that gap, to identify criteria relevant to the design and evaluation of strategies for enabling science teachers to (1) apply philosophical analysis to their teaching and (2) develop the implications of the analysis for the improvement of their teaching.

The research is based on case studies of work with teachers, individually and in small groups. Two important elements in the design of the research are the technique of pattern analysis (from clinical supervision) and the intentions-behavior-effects view of communication.

The basic data of the study are tape recordings of classroom lessons and of teachers' deliberations in the analysis of teaching and the design and evaluation of alternative teaching strategies. Additional data are drawn from the investigator's field notes.

Present data confirm that teachers are willing to examine their methods of teaching, in a non-evaluating setting. As expected, systematic analysis of teaching is difficult to achieve, and strategies of teaching are difficult to change. As hoped, criteria have emerged which seem essential to the process of helping teachers overcome these difficulties. For example, philosophical analysis requires a shift in the teacher's personal perspectives on teaching. Fruitful analysis leading to change is unlikely to occur if the authority for analysis does not move from the traditional personal judgments of a supervisor or other observer to the rational analysis of teaching events according to perspectives seen by the teacher to be relevant.

The study has specific implications for the process by which a distinctive method of science education research can be made relevant to science teachers. The study also speaks to broader questions such as the design and evaluation of inservice education for science teachers.

IDENTIFYING WORLD VIEWS: MECHANISM AND POTENTIAL CONSEQUENCES FOR SCIENCE STUDENTS

Brent Kilbourn
The Ontario Institute for Studies in Education
Toronto, Ontario, Canada M5S 1V6

The research upon which this paper is based is in response to the lack of systematic and comprehensive frameworks in science education for exploring the potential long-term consequences for students of messages about world view. The term "world view" is used to indicate encompassing views of the nature of knowledge and reality. This paper is particularly concerned with what is commonly called a traditional or Newtonian mechanistic world view. Some of its more common features are a reductionist view of knowledge and a view of reality which entails a linear concept of time, a rather strict interpretation of cause-effect, and the idea of discrete particles which have location in time and space. As is widely recognized, one of the implications of this world view is that, ultimately, most (if not all) phenomena can be explained by the complex interactions of these particles. It is a reductionist view of the nature of reality.

The impetus for the research comes from two sources. On the one hand is the recognition that to a significant extent science teaching and science curriculum materials project this mechanistic world view to students. An analysis of a biology textbook supports this claim and is one example among others (e.g., D. P. Ausubel's "An Evaluation of the BSCS Approach to High School Biology," The American Biology Teacher, XXVII, March, 1966, p. 183).

On the other hand, in the past ten years or so there has been persistent and articulate social criticism broadly concerning the quality of life in post-industrial society. Typically, criticism deals with issues like pace-of-life, existential anxiety, consumer ethic (to name a few) and their negative consequences for individuals. Significantly, a substantial part of this criticism attributes root causes for the decline in quality of life to the underlying metaphysics of our social order and the finger is often pointed at the pervasive influence of a mechanistic world view. One of the significant issues emerging from this concerns the extent to which science teaching and science materials unwittingly contribute to a decline in the quality of life because attention is not given to the potential consequences of projecting a mechanistic world view.

A prior question concerns the development of conceptual tools which are rich enough for addressing these issues meaningfully, and this portion of the paper explores one philosophical treatment of the concept of world view which shows promise. Finally, the paper discusses the responsibility of science education to begin attending to the metaphysical bases of scientific disciplines. One implication is that an attempt be made to provide for science students to understand the context in which scientific knowledge and reality lies.

CONCURRENT SESSIONS I

Session ID - Paper Set: Curriculum Dissemination

Presiding: Kenneth D. Moore, University of Tulsa, Tulsa, Oklahoma 74104.

1. "Differences in How Elementary Science Teachers Learn to Use Their Curricula and Their Satisfaction With That Curricula." Donald N. Nimmer, The University of South Dakota, Vermillion, South Dakota 57069.

2. "The Efficacy of Part-Time Consultants to Support Curriculum Dissemination." Jerry G. Horn, The University of South Dakota, Vermillion, South Dakota 57069.

3. "The Impact of Short Term High Intensity Efforts to Disseminate Elementary Science Curricula." Arlen R. Gullickson, National Science Foundation, Washington, D. C. 20550.

4. "Dissemination of Educational Information Through Various Media Channels." Donald N. Nimmer, The University of South Dakota, Vermillion, South Dakota 57069.

DIFFERENCES IN HOW ELEMENTARY SCIENCE TEACHERS LEARN TO USE THEIR CURRICULA AND THEIR SATISFACTION WITH THAT CURRICULA

Donald N. Nimmer
The University of South Dakota
Vermillion, South Dakota 57069

The methods by which elementary science teachers learn to use their curricula are important to know since a thorough understanding of them could greatly increase the effectiveness and efficiency with which curricula developers, textbook publishers, and institutions of teacher education are able to inform elementary science teachers of the proper utilization of the new and revised science curricular materials available to them. As a means of assessing how elementary teachers learned to use their currently taught science curricula, the University of South Dakota, as part of the National Science Foundation sponsored Project TAPE, mailed a questionnaire to a randomly selected group of elementary science teachers in South Dakota, Iowa, Nebraska, and Minnesota in March, 1975. The questionnaire was composed of several distinct sections designed to measure the familiarity with and the use of the National Science Foundation (NSF) supported elementary science curricula of Elementary Science Study (ESS), Science--A Process Approach (S-APA), Science Curriculum Improvement Study (SCIS), and Conceptually Oriented Program in Elementary Science (COPES). The attention of this paper, however, is directed toward the survey's questions explaining how elementary teachers learned to use their current science curricula and how well satisfied they are with those curricula. In addition, this paper explores the differences reported by teachers who use the NSF supported elementary science curricula and those who do not.

Data collected in the survey indicated most (58.3 percent) elementary science teachers learn about their science curricula as they use it. If the individual science teacher is well-trained and experienced in elementary science teaching methods, this mode of self-instruction could indeed adequately prepare one to teach the curriculum. However, as may often be the case, especially in the self-contained classroom where one is expected to teach all subjects, the teacher may not have had the proper background of scientific knowledge and science instructional techniques to properly learn the science curriculum as he uses it. Also, since most elementary science teachers do learn to use their curriculum as they are implementing it, it would seem imperative that textbook publishers make a conscious effort to produce very explicit and detailed teachers' manuals with pertinent references and instructional aids to supplement the teacher's level of expertise.

Teachers using NSF financed elementary science curricula are more active in learning how to use their curricula than are the teachers of the non-NSF programs, i.e., they more frequently learn to use their curricula through college courses, workshops,

independent study, and textbook representatives. This may be attributed to the great emphasis placed upon the NSF curricula in the late 1960's and early 1970's as evidenced by the large number of NSF sponsored workshops, college courses, and extension classes in which NSF curricula were emphasized and taught.

Finally, while most (58.9 percent) elementary science teachers report satisfaction with the curricula they are using, those teachers using NSF curricula express a significantly higher degree of satisfaction than do those teachers using non-NSF curricula.

THE EFFICACY OF PART-TIME CONSULTANTS

TO SUPPORT CURRICULUM DISSEMINATION

Jerry G. Horn
The University of South Dakota
Vermillion, South Dakota 57069

Dissemination of information about the availability of science curricular materials is difficult in any area but particularly so in sparsely populated regions. Project TAPE, a project funded by the National Science Foundation, was designed to disseminate information about elementary science curricula and test the effectiveness of a system that combined the use of direct mailings, mass media, and consultants. This paper addresses the efficacy of using part-time consultants to provide follow-up and support services to a technologically based system of information services.

For an area covering more than 100,000 square miles, six strategically located persons were identified and trained to provide consultation to schools and other interested groups. In most cases, the persons requesting consultation services had listened to audio tapes and/or read promotional materials about the project and the selected curricula (ESS, SCIS and S-APA II).

The efficacy of using part-time consultants was measured in two dimensions. They are as follows:

a. cost effectiveness
b. reception/perceived effectiveness by users

The actual costs for delivering consultation services were broken down by personal fees, travel, and communications. These costs are compared to similar services that could be provided by a centrally located consultant for a similar geographic area.

Data collected via a questionnaire completed by persons requesting consultation services were analyzed and interpreted. Evaluative statements about the perceived value of the consultation phase of the project are provided.

In summary, the cost for using part-time consultants that are strategically located is less than one-half that of centrally located personnel, and among other measures, only 7.2 percent of the respondents expressed a negative opinion about the assistance provided by the consultants. Viewing this with the indication that 54.2 percent of those who felt a need for further services would prefer additional consultation at their school, one can conclude that part-time consultants, as used in Project TAPE, are effective in terms of both costs and perceived benefits by users of their services.

THE IMPACT OF SHORT TERM HIGH INTENSITY EFFORTS TO DISSEMINATE ELEMENTARY SCIENCE CURRICULA

Arlen R. Gullickson
National Science Foundation
Washington, D.C. 20550

Since the early 1960's persons interested in the advancement of science education have placed a great emphasis upon the production of quality curricular materials. During that period comparatively little effort has been made to insure appropriate dissemination of the new curricula. This project focused on testing a model for disseminating new curricula. The premise of the model was that effective dissemination of innovations (including curricula) requires the use of mass media channels to create awareness, followed by more personalized communications to stimulate interest and provide information about the innovation.

The model tested utilized mass media channels - commercial television, radio, and news releases - along with directed mail, brochures, posters, and letters, to secure awareness. Those awareness procedures were backed by a set of Resource Services - toll free telephone access, prerecorded curriculum descriptions, and a group of project supported regional field consultants. General characteristics of the group of science curricula together with information on how to gain information about individual curricula were provided through the mass media. Only through Resource Services could a person gain information about an individual curriculum.

Materials for the project were developed during the fall of 1974 and the primary project dissemination activities were carried out during a two month period January and February 1975.

In order to test the model, the project was set into a quasi-experimental design. All project activities took place within a well defined geographical region (covering all or part of four states). A geographical area outside the project impact region but comparable in demographic characteristics to the project region was used as a control territory.

Pre and post data were collected from both impact and control regions. Systematic sampling procedures were used both pre and post to sample 350 teachers, 225 principals and 125 persons from the general public in the respective impact and control regions. Data were solicited from a total of 2800 persons, 1400 pre and 1400 post. In each case persons were asked their familiarity with curricula used in the dissemination effort. On the post questionnaires, information was also gathered relative to the effectiveness of the project's techniques. Project logs provided additional information regarding user's sources of awareness information.

Results established the effectiveness of the model for creating awareness. Approximately 60 percent of the principals and 30 percent of the teachers in the region were reached by the project awareness messages. However, although familiarity with the curricula increased in the region, the project gains were not greater than gains achieved in the control region. A review of results led to the conclusion that the project's duration was not sufficient to create the desired curricular awareness. Also, the data supported the hypothesis that principals who served as a direct channel and disperser for mailed information to the schools impeded the dissemination effort.

DISSEMINATION OF EDUCATIONAL INFORMATION

THROUGH VARIOUS MEDIA CHANNELS

Donald N. Nimmer
The University of South Dakota
Vermillion, South Dakota 57069

The task of informing residents of the various educational activities being undertaken by their state institutions of higher learning is of great importance to the establishment and maintainance of the institutions' role as a leader in public service and information. The greater the degree to which the institution is able to reach its constituency, the better informed they will become regarding the activities of that institution. However, with the multitude of communicational modes available to them today, the institutions are faced with choosing the media channels that will most effectively and efficiently reach the desired target populations.

In 1974, The University of South Dakota was awarded a National Science Foundation Grant, Project TAPE (Tactics for Applying Programs in Education). This project made extensive use of mass media channels for creating awareness of new curricula--namely NSF supported elementary science curricula. Television, newspapers, radio, educational journals, and directed mailings (letters, posters, and brochures) were the media channels used.

The focus of this paper is a section of the questionnaire mailed to a randomly-selected stratified sample of general public, elementary teachers, and elementary principals at the conclusion of the Project in March, 1975. This questionnaire section investigates the degree to which the samples have become aware of various segments of Project TAPE and the media channels by which they gained their awareness.

The survey results revealed these three conclusions:

1. The use of media channels significantly increased the awareness of principals and teachers regarding Project TAPE, but little or no effect was observed for the general public.

2. A definite difference in the degree of awareness of Project TAPE was noted among the sample strata, with principals being the most aware and the general public being the least.

3. Letters and brochures were the two media channels most frequently cited as informing the respondents of Project TAPE. Television and friend/colleague communication were listed as being next in effectiveness.

CONCURRENT SESSIONS II

Session IIA - Testing and Achievement

Presiding: William B. Mc Ilwaine, Millersville State College, Millersville, Pennsylvania 17551.

1. "A Likert-Type Scale to Assess Attitude Toward Metric Measurement Conversion." Robert L. Shrigley and Cecil R. Trueblood, The Pennsylvania State University, University Park, Pennsylvania 16802.

2. "Development of a Test of Scientific Reasoning." Cornelius Troost, Brock University, St. Catharines, Ontario, Canada L2S 3A1.

3. "Development of an Instrument to Measure Beliefs About Science Teaching." Linda Jones, California State University, Northridge, California 91330.

4. "A Science Skills Test: Development and Field Testing." Gerald L. Abegg and Romualdas Skvarcius, Boston University, Boston, Massachusetts 02215.

5. "Changes in Grade 12 Chemistry Achievement Patterns in Ontario After Establishment of a Modern Course of Study." Alexander Even, The Ontario Institute for Studies in Education, Toronto, Ontario, Canada M5S 1V6.

A LIKERT-TYPE SCALE TO ASSESS

ATTITUDE TOWARD METRIC MEASUREMENT CONVERSION

Robert L. Shrigley

and

Cecil R. Trueblood
The Pennsylvania State University
University Park, Pennsylvania 16802

How would you expect elementary school principals to respond to the following query: When does your faculty expect to switch from English to metric measurement? The typical response is: "Whenever someone in authority tells us we must switch," or "When we finish dealing with reading or another problem area." The basic message is: "We are delaying a changeover."

This attitude is not new and is to be expected. People do not trade the familiar for the unfamiliar unless they are convinced it is absolutely necessary, or that the changeover will result in dramatic change for the better. The intensity to change to new standard units of measurement is related to attitude toward metrics. Therefore, those interested in facilitating the conversion process need to determine the intensity of teachers' attitude related to metrication. Knowing the intensity of teachers' attitude toward metric conversion requires the development of a new attitude scale.

The purpose of this study was to design a Likert-type attitude scale concerning metric measurement for teachers. The procedure used was to develop:

1. a short scale of 20-25 statements requiring only 15-20 minutes to administer

2. an equal number of positive and negative statements

3. statements using 100 subjects that were general enough that they might be used with the general populace later

4. statements that had at least an adjusted item-total correlation coefficient of .30 (a validity factor)

5. a scale with a coefficient reliability alpha of at least .90

The authors wrote 19 statements, the content of which ranged from dual labelling on commodities, conversion from English to metric, as well as the conventional statements showing a liking or dislike for the psychological object, metric measurement.

Keeping the statements general so that they might be used with groups other than teachers meant omitting statements dealing specifically with the teaching of metric measurement. The statements were kept brief, simple and direct. Statements that might be endorsed by many or no one were avoided.

The initial 19 statements were administered to 32 preservice teachers. The result was a coefficient alpha of .79 and an estimated inter-item correlation of .16. Eighteen statements had positive adjusted item-total correlation coefficients ranging from .08 to .79.

The single statement with a negative correlation was, " I will change to metric when I'm forced to." On this statement 91 percent of the sample responded either "strongly agree" or "agree." This meant that those with a favorable attitude and those with unfavorable attitudes toward metric measurement were responding similiarly; therefore, little discrimination could be calculated. When the statement was changed to read, "I am reluctant to change to the metric system," and administered to another group, the responses were spread across the five choices, and the adjusted item-total correlation coefficient of the revised statement was .63.

When the statements on the preliminary scale were analyzed, the wording of three statements was changed and another statement was added. The revised scale was then administered to another group of 61 preservice teachers.

A 20-statement scale, 12 positive and 8 negative, having a reliability coefficient alpha of .92, an estimated inter-item correlation coefficient of .36 and an adjusted item-total coefficient ranging from .31 to .80, has been designed and tested with preservice teachers. The scale is now ready for field testing with other populations and use in experimental studies.

Copies of the attitude scale can be obtained from the authors.

DEVELOPMENT OF A TEST OF SCIENTIFIC REASONING

Cornelius J. Troost
Brock University
St. Catharines, Ontario, Canada L2S 3A1

Under a Ministry of Education grant, a group of faculty members from the Ontario Institute for Studies in Education and Brock University are developing a Comprehensive Test of Problem Solving (CTPS). Based upon a model of problem solving designed by David Ausubel and Floyd Robinson, the CTPS contains six sub-tests: logic, physical science, mathematics, correlation studies, randomization studies, case study, and decision-making.

The physical science component is based upon a concept of causal analysis similar to Mill's Methods. There are currently 15 items requiring 50 minutes of test time. The items carefully reflect the categories resulting from a dimensional analysis of the various sub-types of problem solving. The following list constitutes a preliminary effort to develop a skill sequence for problem solving:

FINDING OUT AND REPORTING SKILL ORGANIZER

I. Establishing a Focus for the Inquiry

II. Selecting a Frame for the Focus

- A. Complexity of the Frame Used
- B. Degree of Independence in Selecting Frame

III. Specifying Sources of Needed Information (Knowledge of Sources of Information)

IV. Locating Information

V. Decoding/Encoding Data at Source

VI. Assessing Adequacy of Data

VII. Recording Data in a Frame

VIII. Determining Unknown Components of the Frame by Projecting (Stored) Knowledge on it

IX. Using an Algorithm to Produce a Summary Number

- A. Origin of Algorithm Used
- B. Complexity of Algorithm Employed

X. Interpretating Data Within a Frame

XI. Extrapolating Data Beyond the Frame

XII. Translating Framed Data into an Initial Public Representation to Suit Various Audiences

XIII. Modifying the Initial Representation for Particular Purposes

The proposed paper will outline our model, the dimensional analysis, and basic test development procedures. The CTPS is primarily a diagnostic tool, so efforts will be made to justify its value as a means of assisting learners and teachers at the 7 - 9 grade level.

DEVELOPMENT OF AN INSTRUMENT TO MEASURE BELIEFS ABOUT TEACHING SCIENCE

Linda Jones
California State University
Northridge, California 91330

Evaluation of teacher education presents many problems, especially in programs whose philosophies demand radical restructuring of teacher behavior. Direct observation of teacher behavior change, although an ideal method, is difficult and expensive. Often, the only practical means of assessment is the use of some instrument that can be applied economically during the physical presence of teachers at the training site. The purpose of this study was to develop an instrument to assess affective changes resulting from training in the teaching of the Elementary Science Study program. There is theoretical and empirical support for the idea that attitudes and beliefs of teachers influence their behavior.

The philosophy on which the ESS program is based may be characterized as quite different from that underlying common practice in elementary schools; for example, perception of the teacher's role as facilitator rather than director. It seems reasonable to expect that teachers must restructure their attitudes and beliefs about teaching science in order to be effective with such a program. In attempt to measure such changes, a forty-item Likert-type instrument was developed. Items consisted of statements to which subjects were asked to indicate their extent of agreement/disagreement on a five-point continuum. The items were based on ideas inherent in the ESS program, particularly those judged to be departures from common classroom practice. Items were phrased so as to have a preferred direction of change, that is, a change toward disagree or agree was judged to be increasing congruence between program philosophy and subjects' beliefs. To avoid test set, the preferred directions of the items were mixed.

The instrument was administered to a group of 22 elementary teachers attending a three-week NSF summer institute, on the first morning and again on the last afternoon. Anonymity was insured by a system of secret identification numbers.

Split-halves reliability calculated on the pretest data was 0.86. Pre-post comparisons of total scores using the t-test for related measures showed a change in the preferred directions which was significant at the 0.001 level.

The t-test on items showed that the means of 21 of the 40 items had changed significantly (0.05 level or better) in the preferred direction. No items showed significant change in the non-preferred direction. Of those items showing no significant change, most were high on the pretest, suggesting that subjects

held the congruent beliefs on those items before the institute began. When the data were analyzed by subjects, 14 subjects (63.6 percent) showed significant change in the preferred direction, one subject (4.5 percent) showed significant change in the unpreferred direction, and seven subjects (31.8 percent) showed no significant change.

If the claim of face validity for the items can be accepted, this instrument appears to have considerable promise in evaluating ESS teacher training programs, even though much work remains to be done. A study of the relationship of measures with this instrument to directly observed teacher behavior is needed. It was felt, however, that a report at this early stage of development would be of interest and possible value to other researchers.

A SCIENCE SKILLS TEST: DEVELOPMENT AND FIELD TESTING

Gerald L. Abegg

and

Romualdas Skvarcius
Boston University
Boston, Massachusetts 02215

With the introduction of laboratory-based science courses, school systems have expressed a need to evaluate student progress in areas not presently tested by standardized achievement, aptitude and basic skills tests. The purpose of this study was to develop and field test such an instrument.

Starting from a list of skills that students were expected to acquire in a laboratory-oriented physical science course, a pool of items was developed. These items fell in the following eight categories:

1. understanding basic terms
2. properties of substances
3. graphs: preparation and interpretation
4. inferences from observations
5. inferences from prior knowledge
6. interpreting numerical relations
7. using laboratory equipment
8. using a model.

From this pool a total of 45 items was selected for use with two forms (Form A and Form B) of the test. Each form consisted of 30 items, with 15 items appearing on both tests.

The pilot versions of both forms were administered in the fall of 1974 and in the spring of 1975 to about 1500 eighth-, ninth-, and tenth-grade students. These students were enrolled in two types of physical science courses and life science courses in five school systems in the East and Midwest. Half of each class was administered Form A; the other half, Form B.

The tests were item analyzed, and a single revised test was produced for piloting in the 76-77 school year. In addition to the item analysis, comparisons of subtest performances of the various groups of students were made. The results of these comparisons indicate that students in laboratory-oriented physical

science classes (IPS) showed significantly greater growth ($p < .05$) on five of the eight categories of the test than did students in other physical science classes or in life science classes. Significant differences were found on (1) understanding basic terms, (2) properties of substances, (3) graphs: preparation and interpretation, (4) inferences from observations, and (5) inferences from prior knowledge. Although no statistically significant differences were found for the remaining three categories, the highest scores were those of the laboratory-oriented physical science students.

CHANGES IN GRADE 12 CHEMISTRY ACHIEVEMENT PATTERNS IN ONTARIO AFTER ESTABLISHMENT OF A MODERN COURSE OF STUDY

Alexander Even
The Ontario Institute for Studies in Education
Toronto, Ontario, Canada M5S 1V6

This study replicates part of a 1964 study designed to examine variations in the attainment of cognitive objectives in high school chemistry. In 1964 most Ontario chemistry students were pursuing a "traditional" course of study. During the latter half of the sixties the traditional course gave way to a "modern" type of course heavily influenced by CHEM Study. By 1972, the year in which data for this study were collected, course innovations and experimental tryouts had consolidated.

It was considered appropriate to compare patterns of achievement before and after establishment of the modern type of course. Patterns of achievement were sought in profiles of residual achivement scores in the selected processes of Knowledge, Comprehension, Application and Analysis described in the Taxonomy of Educational Objectives: Cognitive Domain. Patterns of achievement were examined in groups differing in aptitude, attitude and educational plans.

In the 1964 sample a 60 item end-of-course test, developed over a three-year period, was administered to over 2000 students in 30 Ontario high schools that had been selected at random. Since there had been considerable changes in course content, the test could not be used in its entirety in 1972. A panel composed of experienced teachers and other science educators identified 35 of the 60 items as still having high content validity for the 1972 administration. Additional items were constructed, critically revised by the panel, and then added to the 35 items to make a new test. The new test and the old were equated by the Rasch method so that any given score on the 1972 test could be expressed in terms of a corresponding 1964 score.

In both studies students also wrote a scholastic aptitude test and the Inventory of Choices, a measure of attitudinal orientation. Students were also asked to indicate their educational plans. Almost 3000 students from 34 schools participated in the 1972 study.

Haggard's method of profile analysis, an adaptation of two-way analysis of variance was used to analyze the residual chemistry scores; residuals were defined as raw achievement scores in each Taxonomy category minus the corresponding score predicted from verbal and mathematical aptitude scores by appropriate regression equations.

Achievement patterns classified by attitudinal orientation and educational plans of the 1972 group were found to be, in general, similar to those observed in the 1964 study. However, there were some changes that merit special attention; these changes applied to all students irrespective of attitudinal orientation:

1. The aptitude scores of the 1972 group were substantially lower, on the average, than those of the 1964 group.

2. Substantial declines in achievement were observed across all four levels of the Taxonomy. While some of this decline could be attributed to the drop in aptitude scores, declines were observed after the effect of lowered aptitude scores was taken into account.

3. A substantial portion of the students (about 30 percent) in the 1972 sample had a pattern of achievement in which their performance in categories 2.00, 3.00 or 4.00 appeared to be tied to the ability to recall factual knowledge (category 1.00). Such a relationship was not observed in the 1964 sample where recalling specific information had no relationship to performance in the higher Taxonomy categories studied.

4. Normal achievers (i.e. those not classed as overachievers or underachievers) in the 1972 sample appear to have congruent patterns of achievement in categories 2.00, 3.00 and 4.00 whereas in 1964 the corresponding group was characterized by lack of uniformity in patterns of achievement.

The above findings are cause for concern in view of (1) the trend in modern science courses to minimize the dependence on factual recall, and (2) the increasing awareness of the need to encourage and provide for individual differences.

CONCURRENT SESSIONS II

Session IIB - Paper Set: Piagetian Studies

Presiding: F. David Boulanger, University of Illinois at Chicago Circle, Chicago, Illinois 60680.

1. "Piagetian Schema and Formal Thought." George J. Pallrand, Michael Piburn and Richard Bady, Rutgers University, New Brunswick, New Jersey 08903.

2. "The Development of Correlational Reasoning and Hypothesis Testing Ability." Richard J. Bady, George Pallrand and Michael Piburn, Rutgers University, New Brunswick, New Jersey 08903.

3. "Sex Differences in Formal Reasoning." Michael D. Piburn, George J. Pallrand and Richard J. Bady, Rutgers University, New Brunswick, New Jersey 08903.

PIAGETIAN SCHEMA AND FORMAL THOUGHT

George J. Pallrand
Michael Piburn
Richard Bady
Rutgers University
New Brunswick, New Jersey 08903

Piaget's concept of formal thought has recently attracted considerable attention from science educators. Hypothetical deductive reasoning, characteristic of formal thought, has long been regarded as a necessary precondition to success in many science courses at secondary and college levels. Formal thought has frequently been regarded as a structure d'ensemble within which individuals function equally well across a host of tasks representative of a variety of schema. Experimentally, formal thought has been equated with successful performance on a relatively high proportion of individually administered tasks. Limited attention has been given to performance difficulties on tasks associated with various schema as well as the extent to which various schema call upon different abilities.

A range of Piagetian tasks was administered to subjects at the secondary and college levels to determine if success on one task is related to success on other tasks associated with particular schema and if success on tasks characteristic of one schema is related to success on tasks characteristic of other schema. Various tasks representative of proportional (five tasks), combinatorial (five tasks), and correlational reasoning (two tasks) were administered to 66 subjects selected from three age groups associated with the transition from concrete to formal thought. The Embedded Figures Test (EFT), a measure of field independence, was also administered to investigate the influence of performance factors related to cognitive style that was inherent in the tasks.

The tasks were administered in a rotational sequence by 11 investigators, each responsible for 6 subjects. The investigators met daily for an intensive five week period during which criterion measures and individual scores were established. Scores on individual task results were computed and analyzed, along with scores on related tasks and background variables on an S.P.S.S. computer program.

A correlation matrix of success on various tasks was established. Intertask correlations of the five combinations tasks ranged from no significance to .38, while the correlations of each task with total combinations score ranged from .50 to .72. Similarly the intertask correlations of the five proportions tasks ranged from no significance to .43 while the correlations of each task with total proportions score ranged from .52 to .84. Individual task scores when correlated with total scores for other schema ranged much lower, from .27 to .37. This suggests that elements were common to tasks of particular schema.

Scores on various tasks were subjected to a factor analysis. In three factor analysis, three correlations tasks loaded on the first factor along with EFT and IQ. The M & M's task from proportional reasoning also loaded on this factor. The five combinations tasks weighted on the second factor. All proportional reasoning tasks except M & M's weighted on a third factor along with digit span. Similar results were obtained in a four factor analysis.

Cognitive style as measured by EFT loaded on the same factor as did the correlations tasks suggesting that performance factors were more an issue with tasks of this schema than with others investigated. This analysis suggests that success in Piagetian tasks may call upon differing abilities for particular schema and that no single task is an adequate measure of reasoning within a particular schema.

Abilities related to the Piagetian schema considered in this experiment are important to success in science courses. Perhaps it is an oversimplification to think of formal thought as an overall ability enabling one to function successfully across a broad spectrum of tasks. It may be more realistic to think of the development of certain cognitive abilities, some being realized before others. How these abilities develop and in what rationalities to one another raises questions for further research.

THE DEVELOPMENT OF CORRELATIONAL

REASONING AND HYPOTHESIS TESTING ABILITY

Richard J. Bady
George Pallrand
Michael Piburn
Rutgers University
New Brunswick, New Jersey 08903

High school science courses assume certain logical abilities in students. Among them are the ability to see relationships in data and the ability to test hypotheses about data.

Results of several recent studies using Inhelder and Piaget's correlations task showed a wide range in the age at which adolescents might become able to deal with correlated data. In fact, some studies have found that this ability does not develop until after high school age, if at all.

Studies on hypothesis testing ability have shown that many college students do not test hypotheses in a logical way. No developmental studies have been conducted with pre-college populations, but the poor performance of college students suggests that high school students may lack this ability.

However, these studies may be criticized in that they pose the problems in a way that may be confusing to many subjects. This may account for the variation in some of the results.

Thus, various improvements were made on the tasks to make them better measures of the abilities they claim to top. Also, a second correlation task analogous to Piaget's but different in manner of presentation was developed.

Eleven graduate students at Rutgers University were trained, in an intensive five week period, on the subtleties of administering and scoring Piaget-like tasks. Specific scoring criteria, easily objectifiable, were developed for each task. Each investigator tested six subjects, one of each sex at three age levels (15-22 years) on a barrage of Piagetian tasks, the second correlations tasks, the hypothesis testing task, a standardized IQ text, Witkin's Embedded Figures Test (EFT) and a test of the use of logical connectives. An analysis of variance on total task score by investigator showed no significant effect of investigator.

Correlation tasks were scored on whether or not the subject could compare sets of data and judge their relative correlation as well as generate correlated and non-correlated data himself. The hypothesis testing task was scored according to whether the subject tested the hypothesis by trying to falsify it or merely by looking for confirming evidence only.

The hypothesis testing task, the correlation tasks and the logic task all loaded on the same factor on a factor analysis. No tasks on this factor showed significant development with age.

Performance on the tasks was varied: 70 percent of the subjects tested the hypothesis by falsification, 68 percent gave correct answers on Piaget's correlation tasks (though often their explanations revealed they were right for the wrong reasons), and 48 percent succeeded on the second correlations task.

Results indicate that within the age range of the sample (14-23 years) there is little development in the abilities discussed here. Careful analysis of Piaget's correlation task and explanations given revealed that though correct answers are often given, relatively few subjects are able to deal adequately with the concept of correlation, and very few deal with it in the way Piaget describes. Performance on the hypothesis testing task was higher than might have been predicted from previous studies, perhaps due to the improvements made on the task.

Overall results show that many high school students do not have the logical abilities to deal with data, logical relationships, and hypotheses that we assume they do.

If many high school students do not have the logical abilities that are clearly required for learning and doing science, and if these abilities do not usually develop even after the student leaves high school, then there is a need in the curriculum for procedures to develop such logical abilities in students.

SEX DIFFERENCES IN FORMAL REASONING

Michael D. Piburn
George J. Pallrand
Richard J. Bady
Rutgers University
New Brunswick, New Jersey 08903

The growth of logical thought, as described by Inhelder and Piaget, proceeds more slowly with females than with males. A recent study by Graybill (1975) which indicates that adolescent females lag behind their male counterparts in success on clinical measures of formal operations is consistent with other literature on sex differences in analytical functioning.

Sex differences are not evenly distributed across all Piagetian tasks. They are most pronounced in those cases that involve complex equipment and a multiplicity of variables, and are diminished or disappear in the case of tasks that offer fewer perceptual distractions.

The data array itself may be a negative performance factor which prevents some subjects from demonstrating their competence in logical thought. One such factor may be field-dependence-independence, described by Herman Witkin as the ability to disembed specific information from the overall field.

Data for this study were gathered during the summer of 1976, by eleven investigators, from a sample of thirty males and thirty-six females, ranging in age from 162 to 308 months. Analysis of variance across data collected by separate investigators showed no experimenter effect.

Twelve measures of formal reasoning were used, eight clinical tasks and four adaptations to a pencil-and-paper format. These assessed either proportional, combinatorial or correlational reasoning.

Other measures included the California Short-Form Test of Mental Maturity, the Embedded Figures Test, Digit Span, a hypothesis testing task and the use of logical connectives.

There were significant sex differences in the number of tasks completed only in the case of those requiring proportional reasoning, with females achieving lower success rates and mean scores.

Field dependence-independence was defined as the total time, in seconds, to complete the Embedded Figures Test. Females achieved a higher mean score (753 seconds) than males (632 seconds), and were thus more field dependent. Witkin cites numerous studies which show this relationship, and asserts that females, as a group, tend to be more field dependent than males.

Field dependent subjects in this study were significantly less successful at tasks requiring proportional or correlational reasoning than were field independent subjects. Only the measures of combinatorial reasoning seem unrelated to field dependence-independence.

Lower mean scores of females on proportionality tasks may be more the result of their inability to disembed information from a complex data array than from any deficiency in logical ability. Studies now in progress, involving the pattern of solution used by each subject, may shed further light on the relationship between type of task and sex differences in performance.

Both researchers and educators should be aware of the subtle interrelationships that exist between cognitive style variables such as field-dependence-independence and success on the problem solving tasks used by Piaget.

Differences in success on such tasks may arise from far different causes than we might initially assume, and educational programs to remediate failure may be inappropriately designed.

Graybill, Letitia. "Sex Differences in Problem-Solving Ability." Journal of Research in Science Teaching, 12:341-346, 1975.

CONCURRENT SESSIONS II

Session IIC - Training Session: System Dynamics

Presiding: Martin L. Goodson, Alabama A & M University, Normal, Alabama 35811.

"System Dynamics: Strategies and Materials."
Nancy H. Roberts, Leslie College and M.I.T., Cambridge, Massachusetts 02139.

SYSTEM DYNAMICS: STRATEGIES AND MATERIALS

Nancy H. Roberts
Leslie College and M.I.T.
Cambridge, Massachusetts 02139

System dynamics is a field which seeks to better understand the process of change in systems by focusing on three notions about life:

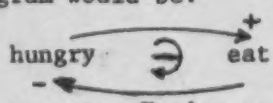
1. Life is dynamic, continually changing over time.

2. Feedback exists in most situations. Feedback suggests that an action taken by a person or thing eventually affects again a future action by that person or thing.

3. Life is better understood from a systems perspective - a perspective that attempts to understand the relationship between all elements affecting a complex situation, rather than understanding a total situation by studying one element at a time.

When analyzing a problem from a system dynamic perspective, a researcher goes through three basic phases.

In the first phase the researcher develops visual feedback diagrams showing the cause-and-effect structure of the system being studied. An example of a simple feedback relationship expressed in such a diagram would be:



Being hungry causes one to eat. Eating causes one to be less hungry, causing one to eat less, eventually causing one to be hungry again.

The second phase of system dynamics is model building. Using DYNAMO (a computer simulation that steps through time and graphically presents the behavior of the system) or an equivalent computer simulation language, the researcher states in precise mathematical form the cause-and-effect relationships he has identified.

During the third phase the researcher simulates, with the aid of a computer, the model he has built. Later phases involve model validation, computer experimentation, redesign and continued iteration of this overall cycle.

This training session proposes to give the participants specific techniques and materials for learning and teaching the basic concepts of understanding complex problems from a systems perspective. Participants will understand how simple feedback structures can lead to exponential growth, decay, and fluctuations in systems. In addition, they will appreciate how understanding

more complex feedback structures can deepen one's understanding of any system. Specific skills include diagramming causal relationships, expressing system characteristics as time graphs, and expressing qualitative relationships precisely in graphical terms.

The exercises to be used in this training session are predominately drawn from material used in graduate courses at M.I.T. Some exercises, however, have been revised so they are suitable for use with children in elementary school. All the materials have been field tested with students from grade one to continuing education students at M.I.T. The same teaching strategy seems effective for all ages. Therefore, the goal of this session is for the participants to learn both a new research tool as well as a teaching strategy. The appended bibliography contains examples of system dynamics research applications.

The goals for system dynamics as a classroom teaching strategy are: 1) to increase students' confidence that complex problems are approachable; 2) to enable students to become more insightful decision makers; 3) to strengthen students' thinking skills and 4) at the high school level, to bring the computer into classrooms as a research tool.

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CONCURRENT SESSIONS II

Session IID - Symposium: Science Enrollments

Presiding: Ronald D. Anderson, University of Colorado, Boulder, Colorado 80309.

"Uninformative Enrollment Data"

Biology

James T. Robinson
Biological Sciences Curriculum Study
Boulder, Colorado 80303

Chemistry

John F. Schaff
University of Toledo
Toledo, Ohio 43606

Junior High

Ernest Burkman
Florida State University
Tallahassee 32304

Earth Science

Victor J. Mayer
The Ohio State University
Columbus, Ohio 43210

Physics

Fletcher G. Watson
Harvard University
Cambridge, Massachusetts 02138

Publisher

Nicholas Moore
Holt, Rinehart and Winston
New York, New York 10017

National Center for Education Statistics

Logan C. Osterndorf
Department of Health, Education, and Welfare
Washington, D.C. 20202

CONCURRENT SESSIONS III

Session IIIA - Curriculum

Presiding: Harold R. Hungerford, Southern Illinois University, Carbondale, Illinois 62901.

1. "Cognitive Preferences in Biology of Students Participating in a Secondary Science Training Summer Program." Vincent N. Lunetta, The University of Iowa, Iowa City, Iowa 52242 and Pinchas Tamir, Hebrew University, Jerusalem, Israel.

2. "The Development and Implementation of the Levels of Use Observational Inventory (LoUOI): An Instrument to Aid in the Adoption of an Innovation Process." Joel A. Colbert, University of Kansas, Lawrence,Kansas 66044.

3. "Does More Time Yield More Learning?" John T. Wilson, The University of Iowa, Iowa City, Iowa 52242.

COGNITIVE PREFERENCES IN BIOLOGY OF STUDENTS PARTICIPATING IN A SECONDARY SCIENCE TRAINING SUMMER PROGRAM

Vincent N. Lunetta
The University of Iowa
Iowa City, Iowa 52242

and

Pinchas Tamir
Hebrew University
Jerusalem, Israel

Cognitive preferences constitute a kind of cognitive style which is acquired as a result of certain life and learning experiences. In turn, they interact with other individual characteristics, such as abilities, thereby influencing further outcomes in subsequent learning under specific modes of instruction.

Heath (1964) identified four cognitive preference modes: Recall (R), Principles (P), Questioning (Q), and Application (A). These modes have been used in a number of studies, including the present one, the objectives of which are to:

1. identify the cognitive preference in biology of able, science-oriented high school students;
2. identify the relationships between cognitive preference patterns and certain background variables;
3. compare the results obtained by normative with those obtained by ipsative procedures;
4. identify the degree of cognitive preference dependence on specific biological topics.

A Biology Cognitive Preference Test (BCPT) was printed in two forms. In Form A the first 20 items required ranking (ipsative) while the last 20 items required rating on a 4-point scale (normative). In Form B the order was reversed. The first 20 items required rating and the last 20 items required ranking. The items of BCPT were also categorized under different biological topics.

The results were analyzed by a special computer program which yields mean scores, standard deviations and reliability coefficients. Further analyses included: intercorrelations, multiple regression, analysis of variance, t tests. The following scored were computed: R, P, Q. A, Q-R, P-A (Q minus R and P minus A are derived scores). Each of these was computed for ipsative, normative, and combined, namely normative + ipsative scores.

The tests were administered to 177 high school students who participated in a 6 weeks Secondary Science Training Program (SSTP) in the summer of 1976. These participants were selected on the basis of their high achievement and strong interest in science. A number of background variables were studied including: sex; year in high school; general achievement; high school biology grade; nature of high school course; geographic region; hobby involving plants or animals; frequency of free-reading of scientific literature; prospective major field of study in college.

The results showed that the students were a select group with very high preference for Q, high preference for P and low preference for R. This pattern when compared with that of other populations of high school students reveals an exceptionally high level of intellectual curiosity and a desire to learn more. While only weak correlations were found between cognitive preferences and most of the background variables, all of them were in the expected direction. One important finding was the 'higher Q-lower R' preferences of BSCS (Blue and Yellow) students compared with those who had traditional courses. The effect of the nature of the subject matter on cognitive preferences is also reported.

The correspondence observed between expectations and performance provides strong support to the validity of the cognitive preference test as well as to the construct of cognitive preferences. The findings of the effect of specific biological topics is also an important contribution as are the methodological implications of the results obtained with ipsative and normative procedures.

THE DEVELOPMENT AND IMPLEMENTATION OF THE LEVELS OF USE OBSERVATIONAL INVENTORY (LoUOI): AN INSTRUMENT TO AID IN THE ADOPTION OF AN INNOVATION PROCESS

Joel A. Colbert
University of Kansas
Lawrence, Kansas 66044

The purpose of this research was to develop and implement an observational instrument to measure the process of innovation adoption as described by the Concerns Based Adoption Model, developed at the University of Texas Research and Development Center. One dimension of this model is the Levels of Use of an Innovation (LoU). There are seven levels of use ranging from no knowledge of the innovation through routine use to looking for better alternatives. The literature suggested that individuals and groups proceed through these levels in the process of innovation adoption. In the past an interview was employed to determine an individual's level. The present paper describes an observational inventory that was developed to complement the interview and provide information by observing the teacher in the actual use of the innovation.

The sample included 33 elementary school teachers who were involved in a National Science Foundation Institute during the summer of 1975. The purpose of the Institute was to familiarize the participants with the Science Curriculum Improvement Study (SCIS) Curriculum, which they would be using the following fall. SCIS constituted the innovation that would be adopted. The inventory was developed based upon the work at the institute and was content validated by a panel of experts familiar with SCIS and Levels of Use. The LoUOI was administered two times to all participants. Concurrent validity was determined by correlating the Levels of Use measured by the LoUOI with the LoU interview. The concurrent validity was 0.71. Interrater reliability was determined by using two independent judges. There was perfect interrater reliability. Test-retest reliability, correlating the LoU of both administrations, was 0.94. The results indicated that a valid and reliable estimate of the Levels of Use could be determined if the particular teacher was observed in the actual process of using the innovation.

When a new curriculum or any other innovation is adopted by a school or system, it should not be assumed that the implementation of the innovation will result in smooth and effective use immediately. The literature suggests that for complex innovations it may take up to three to five years to achieve routine use. However, by being aware of the Concerns Based Adoption Model and by using instruments, such as the LoUOI and the LoU interview, strategies can be developed to resolve problems, and in general, smooth out the adoption process.

DOES MORE TIME YIELD MORE LEARNING?

John T. Wilson
The University of Iowa
Iowa City, Iowa 52242

Many science curriculum developers have assumed that time and achievement are highly correlated. This assumption is reflected by curricular materials which provide more time via "self-pacing" or "training to criterion". Carrol (1963) has proposed that the amount of time for a student to obtain criterion and complete the learning task be considered as an aptitude. Many have interpreted this proposal to mean that given enough time all students can obtain criterion. There is little comfort in thinking that all that is needed to produce geniuses like Bertrand Russell is to give students enough time. If time functions as an aptitude, then its application to instruction should not be to "use more of it" but rather that instructional conditions will interact with time, some interactions being more fruitful than others. The astute instructional designer can capitalize on these more fruitful interactions.

The purpose of this study was to assess the effectiveness of time as an instructional variable in relation to learning within various types of instructional settings while attaining various learning outcomes.

Several studies where time was measured and reported were reevaluated in terms of the above objective. In each study, subjects were randomly assigned to treatment conditions which generally were parallel in design. Typically, the studies all presented the Ss with similar instructional tasks, allowing for as much time as the Ss needed to complete the task. Controlled differences occurred between groups in the type of instructional cues, sequence of materials, or modes of presentations.

Original data from each study were reanalyzed using analysis of variance and multiple linear regression, following the statistical analysis common to ATI (Aptitude x Treatment Interaction) studies. Subjects in the studies included elementary school children, high school aged students, and college aged students. None of the original studies had previously reported any such analysis in published reports.

In several instances, the amount of time spent in an instructional treatment was negatively related to performance. Then performance was regressed on time using a multiple-linear regression model, several negatively sloped lines were disclosed for some treatments while positively sloped lines occurred for others. For example, in one study all subjects read the same instructional materials with the between group difference being whether they answered questions as they read, highlighted the materials as they read, both of these, or none of these. Time was positively

related to performance on retention measures when Ss either answered questions or highlighted while reading; time was negatively related when Ss did both or neither while reading. This would indicate that "more time" is not of itself an adequate instructional modification. Alternative treatments must be considered where instructional cues, sequence, and mode of presentation are matched to learner abilities and predispositions.

With the growing use of "self-paced" and "criterion referenced" materials, careful attention must be given to the notion that more time yields more learning. This study reports ample evidence to challenge this assumption.

Carrol, J. A. "A Model for School Learning." Teacher's College Record, 64:723-733, 1963.

CONCURRENT SESSIONS III

Session IIIB - General Research

Presiding: Martha K. Piper, University of Texas at Houston, Houston, Texas 77004.

1. "The Philosophic Consistency of Science Teachers' Opinions About the Structure of Scientific Laws and Theories." Ronald E. Rowe, Beaver College, Glenside, Pennsylvania 19038.

2. "Cognitive Dissonance as a Means of Effecting Changes in School Related Attitudes." Robert L. Steiner, The Ohio State University, Columbus, Ohio 43210.

3. "The Acquisition of the Conservation of Number by Preschool Children Using Didactic and Alternative Example Methods of Instruction to Examine Aptitude X Treatment Interaction." Albert W. Strickland, III, Indiana University, Bloomington, Indiana 47401.

4. "The Relative Effectiveness of Teacher Versus Administrators Curriculum Conferences as Agents of Change." Euwe van den Berg and John T. Wilson, The University of Iowa, Iowa City, Iowa 52242.

THE PHILOSOPHIC CONSISTENCY OF SCIENCE TEACHERS' OPINIONS ABOUT THE STRUCTURE OF SCIENTIFIC LAWS AND THEORIES

Ronald E. Rowe
Beaver College
Glenside, Pennsylvania 19038

The development, in students, of an understanding of the nature of science has frequently been mentioned in published articles about the goals of science education and in the lists of objectives written by science teachers and developers of instructional materials. The problem of analyzing what is meant by the concept "the nature (or structure) of science" has been the focus of studies by Schwab, Robinson, Connelly, Herron and others. A parallel problem, the determination of how science teachers conceptualize the nature of science, has not been resolved. Previous investigations in this area have yielded conclusions which were conflicting or insignificant. Two explanations have been advanced for the prevalent confusion:

1. the concept is too broad and diverse to measure in a single investigation, and

2. the instruments used previously failed to represent the diverse opinions existent in the philosophic community.

The purpose of the current study, therefore, was to determine science teachers' conceptualizations of the nature of scientific laws and theories, a subset of the "nature of science" concept, in depth. The facilitation of this inquiry required the generation of a new instrument, based on the writings of several philosophers of science who reflect the present diversity of opinion in this field.

The method utilized was that of a descriptive survey, rather than an experimental study, and the data were analyzed and reported in terms of descriptive statistics.

An opinionnaire containing 56 statements about laws and theories was constructed. The statements represented:

1. the published viewpoints of five philosophers (Carnap, Hempel, Popper, Kemeny, Lachman), and

2. logical alternatives.

Statements were grouped for analysis according to the following scheme:

1. definitions and characteristics of laws and theories,

2. the linguistic structure of laws and theories,

3. the formulation of laws and theories,

4. the functions of laws and theories, and

5. the corroboration of laws and theories.

Fifty science teachers were randomly selected from a total population of 1056 teaching in the public middle and junior high schools in Wisconsin during the autumn of 1975.

Respondents were instructed to choose one of four modified Likert-type responses: agree, disagree, don't know, or unclear.

Data analysis included determination of philosophic consistency from group and individual data, item analysis to identify statements eliciting high ratios of disparate responses, and identification of philosophers whose viewpoints received high and low percentages of "agree" responses.

Wisconsin middle grade science teachers held divergent opinions concerning the structure of laws and theories. Only eleven statements received "agree" responses from more than 75 percent of the respondents. The teachers were philosophically inconsistent in their responses, both individually and as a group. Twelve statements received high ratios (greater than 0.40) of disparate responses. The set of statements identified with Lachman received the greatest degree of endorsement, while Popper-statements received the least.

Replication of the investigation with varying populations could (if results are consistent) enable construction of a model of science teachers' conceptualizations of laws and theories. The model could be used to determine congruencies between views expressed in instructional materials and by teachers. Implications for teacher training are also apparent.

COGNITIVE DISSONANCE AS A MEANS OF EFFECTING CHANGES IN SCHOOL RELATED ATTITUDES

Robert L. Steiner
The Ohio State University
Columbus, Ohio 43210

Much science education attitude research has lacked an established theoretical framework. Shrigley (1976) has recommended that theories of attitude change identified and developed by social scientists be used as a basis for attitude studies in science education. The present research which attempted to change some school-related attitudes was based on one such theory, that of "Cognitive Dissonance" (Festinger, 1957).

"Cognitive Dissonance is a state of tension that occurs when an individual simultaneously holds two cognitions (ideas, attitudes, beliefs, opinions) that are psychologically inconsistent" (Aronson, 1972). The dissonance state is unpleasant and the individual experiencing dissonance is motivated to reduce it. One application of cognitive dissonance theory, to produce an attitude change as a means of dissonance reduction, is to induce a subject to behave in a manner contrary to his held attitude. The subject is made aware of the inconsistency in his behavior and his attitude, thus producing dissonance. Since the behavior is already of record, the logical means of dissonance reduction is through an attitude change more in line with the behavior.

In this research, the treatment consisted of students preparing a short videotape extolling positive virtues of either 1) science as a school subject and advocating that peers enroll in science, or 2) the school lunch program and encouraging peers to eat school lunches. The student was told that the tape was to be shown to his peers. Dissonance should be created for any student who has an attitude toward the referent counter to what he was extolling on the videotape. Each videotaping session was private wherein the student and researchers worked in preparing a serious and professional tape reflecting a positive attitude toward the particular referent. During the session the student repeatedly saw and heard himself expressing a positive attitude toward the referent and encouraging a particular course of action for peers. Theory suggests that the degree of dissonance experienced in the subjects will be a function of their initial attitudes and predicts the greatest attitude change for those experiencing the greatest dissonance. Although change in attitude toward science as a school subject was a prime concern to the research, attitude toward school lunch was also assessed and included as a treatment. This was to disguise the purpose of the treatments, to test the theory in another school-related context and to use the results of the two cognitive dissonance treatments on the criterion measures as controls for each other.

Ninth grade life science students of a local high school were administered a Likert-type attitude measure to assess their attitudes toward science as a school subject and toward school lunches. Students were dichotomized using median scores as having high or low attitudes toward each referent. The four possible attitude categories (high science-high food, high science-low food, low science-high food, low science-low food) contained approximately equal numbers of students. Twenty students from each of the four categories were randomly assigned to either the science or lunch treatment, ten to each. The treatment was administered individually over a ten day period after which all students were again administered the criterion attitude measures. One hundred twenty-three students took both the pre and post test measures, (33 in the science treatment group, 35 in the food treatment group, and 55 in a non-treatment group). A three-way analysis of covariance using the attitude pretest as a covariant was used to analyze the data for the science and food attitude criterions.

The criterion measure consisted of 35 Likert-type items. Twenty items composed the attitude toward science as a school subject criterion measure, 14 items composed the attitude toward school lunch criterion measure and 1 item assessed student attitude toward school. Pretest Cronbach alpha reliabilities for the two scales were greater than 0.90 for both scales.

The analysis revealed a significant treatment effect ($p < 0.05$) for the science treatment on the science attitude criterion. The post test attitude toward science as a school subject for the science treatment group was significantly higher than that of the lunch treatment and non-treatment groups. The analysis did not reveal any difference between the high and low science attitude students.

The analysis of the attitude toward school lunch criterion revealed significant differences ($p < 0.05$) for the high and low science attitude groups. The low science attitude students scored significantly lower than the high science attitude students on the criterion measure. The treatment effect was not significant.

The cognitive dissonance treatment successfully produced attitude changes in the student's attitude toward science as a school subject, but did not produce changes in the student's attitude toward school lunch. Differential treatment effects for students with initial high and low referent attitudes as predicted by the theory were not revealed.

This study represents an attempt to purposely effect a change in school-related attitudes using one of the accepted attitude change models from the social science literature. Although the results were not completely compatible with the theory, limited support is provided and future potential research in areas affecting attitude change in science education is suggested.

Aronson, Elliot. The Social Animal. New York: Viking Press, 1972.

Festinger, Leon. A Theory of Cognitive Dissonance. Stanford: Stanford University Press, 1957.

Shrigley, Robert L. "Generating Theoretical Bases for Attitude Research in Science Education: The Learning Theory Approach." A Paper presented at 49th Annual Meeting of the National Association for Research in Science Teaching, San Francisco, April 23-25, 1976.

THE ACQUISITION OF THE CONSERVATION OF NUMBER BY PRESCHOOL CHLLDREN USING DIDACTIC AND ALTERNATIVE EXAMPLE METHODS OF INSTRUCTION TO EXAMINE APTITUDE X TREATMENT INTERACTION

Albert W. Strickland III
Indiana University
Bloomington, Indiana 47401

The purpose of this study was to examine the presence of conservation aptitudes in subjects determined to be in the Piagetian preoperational stage and, secondly, examine conservation performance using an Aptitude x Treatment Interaction (ATI) model in which the differential effects of impulsivity, reflectivity and verbal ability were examined in relation to Didactic and Alternative Example methods of instruction. It was expected that the treatment conditions would influence the conservation performance of the preschool children. Furthermore, it was anticipated that learner characteristics would interact significantly with treatment conditions.

Thirty subjects were randomly assigned to one of three treatment groups. Subjects were administered aptitude tests representing impulsivity-reflectivity, verbal and full scale IQ in addition to treatment materials and pretest, posttest performance measures. The pretest. posttest measures were designed to indicate conservation of number performance and acquisition.

Comparison of performances on posttest scores indicated a strong significant F ratio where conservation performance had been altered by the treatment conditions. Using an analysis of covariance technique, it was found that there was no interaction between impulsivity-reflectivity and treatment. However, when the categorical variables of impulsivity-reflectivity were removed and the continuous variables of latency score and error score were viewed, a significant interaction appeared between treatment and aptitude. These data suggested that impulsive students performed significantly better in the Verbal Didactic method. The verbal and full scale aptitudes did not interact significantly with either treatment although they were significantly correlated with the criterion scores.

THE RELATIVE EFFECTIVENESS OF TEACHER VERSUS ADMINISTRATOR CURRICULUM CONFERENCES AS AGENTS OF CHANGE

Euwe van den Berg

and

John T. Wilson
The University of Iowa
Iowa City, Iowa 52242

As a part of its curriculum implementation efforts the National Science Foundation has subsidized, in the past, curriculum conferences which were meant to familiarize administrators and/or teachers with Foundation-supported curricula and teaching strategies. It was hoped that these conferences would eventually lead to the adoption/adaptation of National Science Foundation curriculum materials as well as to the implementation of appropriate teaching strategies.

This paper describes a longitudinal (two year period) evaluation of three conferences, one for administrators and two for teachers, all at the elementary school levels. Of particular concern was the following issue: "Are curriculum conferences for administrators equally effective as those for teachers?" Effectiveness was defined in terms of the variables listed in the next section.

The curriculum conferences lasted 10 days. Participants were introduced to Foundation-supported elementary science curricula (ESS, ES, SAPA, SCIS, HSMS and MACOS) by means of lectures and discussion sessions on the history and general philosophy of the curricula followed by extensive "hands-on" activities. Format and teaching staff were the same for each of the conferences.

The following variables were chosen as a means to compare the effectiveness of conferences for teachers and administrators: (1) the percentage of non-users that adopted NSF curricula; (2) the number of students, grade levels and schools affected; (3) attrition rates of participants leaving their school, and (4) the percentage of participants implementing relevant teaching strategies.

Several data sources were used in a post hoc design utilizing the chi-square test for independent samples and the Fischer exact probability test for the statistical analysis.

The following data sources were used:

1. A questionnaire was mailed 1-1/2 years after the conferences; the response rates were 84 percent for administrators and 72 percent for teachers.

2. Requests from participants for follow-up activities such as additional inservice training.

3. Case studies from information provided by local science coordinators.

4. Observations from audio-tapes and follow-up visits to classrooms in the schools of participants.

5. Demographic data concerning size of district, school, availability of trained supervisory assistance.

Differences were examined on the .05 level of significance.

The adoption rate among administrators who were not using NSF materials before the conference was significantly higher than among teachers who were non-users. Significantly fewer administrators left their profession than teachers (after two years). The number of students, grade levels and schools affected was higher for administrators than for teachers. Descriptive data about the actual classroom use of national curricula do not favor either teachers or the administrators. Additional data are being collected to verify original observations.

This study suggests that introductory curriculum conferences are more effective when participants are elementary administrators than when they are elementary teachers, if the variables identified in this study are accepted as a basis for judgment. In addition it was found that conferences for administrators have some important delayed successes. For example administrators started a district wide science curriculum committee after returning from the conference, resulting in an adaptation of an NSF curriculum two years after the conference. No such delayed responses occurred for teacher conferences.

CONCURRENT SESSIONS III

Session IIIC - Paper Set: Complex Scientific Problem Solving

Presiding: Joy S. Lindbeck, University of Akron, Akron, Ohio 44304.

1. "The Wooly Mammoth as a Computer-Based Complex Problem-Solving Tool." Michael Szabo, The Pennsylvania State University, University Park, Pennsylvania 16802.

2. "A Multiple Discriminant Analysis Study of Scientific Problem-Solving Ability in a Computer-Based Learning Environment." Thomas Rhoades, Anne Arundel County Schools, Annapolis, Maryland 21401 and Michael Szabo, The Pennsylvania State University, University Park, Pennsylvania 16802.

3. "A Comparison of Individual and Dyadic Performance on a Computer-Based Science Problem-Solving Task as a Function of Mental Ability." Melissa Berkowitz and Michael Szabo, The Pennsylvania State University, University Park, Pennsylvania 16802.

THE WOOLY MAMMOTH AS A

COMPUTER-BASED COMPLEX PROBLEM-SOLVING TOOL

Michael Szabo
The Pennsylvania State University
University Park, Pennsylvania 16802

The purpose of this paper is to describe the operation of a computer-based research tool used in studying human problem-solving in a real, complex, multi-stage, and scientific problem. Early applications will be summarized and two research studies which used the mammoth will follow this presentation in this paper set.

In the past, problem-solving studies using simple problems (those requiring only one operation) have dominated the field. Further, few of these studies involved science. The criteria often studied were attainment of solution and solution latency. Recent work (Bloom and Broder, Butts, Shulman and Elstein, and Simon) clearly indicates that: 1) the processes or strategies employed are more revealing than the achievement of a solution, and 2) the study of processes requires the presence of a complex multi-stage problem. Further analysis suggests the desirability of confronting the subject with a real-time interactive environment to: 1) react to different processes (e.g., requests for data) in a high fidelity manner, 2) monitor strategies employed by the problem-solver, and 3) permit larger numbers of problem-solvers to confront the problem without unreasonable demands on the part of the researcher. From this analysis, the Wooly Mammoth was "programmed" onto an interactive Computer Assisted Instruction (CAI) System.

The mammoth problem is: 1) real, 2) complex enough to elicit inquiry and rational thought, and 3) capable of directing certain processes (e.g., data utilization) to be used. The three components of Mammoth include: 1) confrontation, 2) a pool of data for testing hypotheses, and 3) a set of heuristics (to "guide" the problem-solver during the experience).

The confrontation describes some Mammoth finds and ends "How does one go about killing healthy, robust, five-ton animals leaving no apparent cause of death and then manage to preserve them in the condition described using only natural means?"

At this point, the computer program suggests that the student(s) formulate hypotheses to explain these discrepant findings. Next, the computer asks the student to request data which might be useful in testing one or more of the hypotheses. With no knowledge of the structure of the data bank, the student makes a natural language request for data.

Available data are displayed to the student. If no match between request and data is found, the student is asked to reconsider or reconstruct the data request.

Mode I (Problem) of Mammoth then recycles through the data request-data display cycle until the problem-solver has exhausted all possibilities. Mode II (Heuristic) guides the process by requiring the student to make some conclusion each time it displays new data. In addition, mode II provides "hints and cues" based on the consistency of data search (based on a priori linkages or chains of data) and evaluates conclusions based upon the sufficiency of evidence (data) seen by the student. This technique is a subtle attempt to "shape" the problem-solving strategies used by the student.

To date, Mammoth has been used to train prospective science teachers and study complex problem-solving as described in the following two studies.

A MULTIPLE DISCRIMINANT ANALYSIS STUDY OF SCIENTIFIC PROBLEM-SOLVING ABILITY IN A COMPUTER-BASED LEARNING ENVIRONMENT

Thomas Rhoades
Anne Arundel County Schools
Annapolis, Maryland 21401

and

Michael Szabo
The Pennsylvania State University
University Park, Pennsylvania 16802

The objective of this study was to investigate selected processes and strategies used by subjects confronted with a complex problem-solving task in science. The processes monitored were those most commonly judged important for the solution of simple problems. This investigation attempted to determine whether good problem-solvers can be differentiated from poor problem-solvers by individual differences in processes they utilized when attacking a complex problem.

Problem-solving studies which involve only one operation such as seriation or analysis have been criticized as having little applicability to the real world or the classroom. Successful problem-solving across a wide variety of problems depends upon the solution processes rather than any one solution. If processes are to be examined, then complex problem-solving tasks involving unlimited responses and multi-stage operations must be used. Few experimental studies have investigated the strategies or processes used in complex problem-solving.

The problem-solving variables investigated included processes which theoretically differentiate good from poor problem-solvers: 1) time in problem and hypothesis formation; 2) number and quality of hypotheses produced; 3) heuristic cues and hints during problem solution; 4) sex; 5) intelligence; 6) scientific training; 7) level of education; and 8) amount of notes recorded. The criterion variables included: 9) amount of data received; 10) amount of unique data received; 11) amount of data requested; 12) time spent considering positive, negative, and neutral data; 13) time spent on the problem; and 14) quality of final conclusion.

Volunteer college students (N = 111) participated in the study. The experimental task was to "determine" possible causes of the death of the wooly mammoth found frozen and preserved in the Arctic Tundra. The problem task was presented in a Computer Assisted Instruction environment (Szabo and Rhoades, 1976) which: 1) presented the problem; 2) served as a data source; 3) covertly monitored processes useful in problem-solving; and 4) provided statements (heuristics) which help structure the flow of the solution effort.

Criterion variables were dichotomized at the mean to operationally define good and poor problem-solvers. Each dichotomized criterion variable formed the basis for a two group step-wise multiple discriminate function analysis with the problem-solving variables serving as the predictor variables.

Four major results were obtained. First, amount of notes, educational level, scientific training, intelligence, and number of hypotheses have significantly positive discriminant coefficients and time spent forming hypotheses was a significantly negative discriminator for classifying good and poor problem-solvers on the amount of data requested and obtained.

Second, number and quality of hypotheses had significantly positive discriminant coefficients in classifying subjects who were successful problem-solvers in the amount of time spent considering positive and negative data.

Third, average hypothesis quality, scientific training, and amount of notes had significantly positive discriminant coefficients for subjects who did and did not reach solution.

Finally, heuristics had no differential effects on the criterion variables.

This study sheds light on the relative contribution of selected problem-solving processes (e.g., hypothesis formation) to solving complex science problems. Implications for future research and training for effective data utilization will be discussed.

A COMPARISON OF INDIVIDUAL AND DYADIC PERFORMANCE ON A COMPUTER-BASED SCIENCE PROBLEM-SOLVING TASK AS A FUNCTION OF MENTAL ABILITY

Melissa Berkowitz

and

Michael Szabo
The Pennsylvania State University
University Park, Pennsylvania 16802

This study was conducted to examine effects of mental ability upon problem-solving processes of individuals and dyads confronted by complex science problems.

Lorge and Solomon suggested that group superiority results from increased probability that one of its members can solve the problem, which is, in turn, a matter of ability. Steiner's Complementary Task Model suggests that group members pool complementary information enabling the group to exceed the performance of its best individual. Both models imply grouping by ability interaction.

Shulman and Elstein categorize studies into those which examine the processes used to solve problems, and those which examine input-output relations. The present study examines how subjects form problems, the usefulness of information, and processes used during problem solution. A complex problem is needed to elicit problem-solving processes (e.g., a variety of hypotheses to account for a large amount of data followed by hypothesis evaluation and the formulation of conclusions based upon the data search).

For process criterion in problem-solving, some researchers focused on increasing fluency; Torrence studied Individual and Dyadic Problem-Solving. Other process criteria suggested by the literature include time spent and the use of positive, neutral, and negative data.

The study used a 2 X 3 design with two levels of grouping: individuals and dyads, and three levels of mental ability: high (H), high plus low (HL), and low (L). The experimental problem was to solve the riddle of the frozen wooly mammoth, a complex problem which requires the subject to hypothesize, request information, and form new hypotheses concerning possible causes of the death of the mammoth. An interactive computer assisted instruction system was used as a data source, feedback mechanism, and monitoring system which tracked subjects' problem-solving activities.

Eighty undergraduates participated in the study. The dependent variables were: number of hypotheses, number of data requests, number of data matches, total times, time expended for hypothesis,

proportion of positive, negative, and neutral data, and time spent reading positive, negative, and neutral information. Each of these variables was analyzed with a 2 X 3 between subjects ANOVA.

A significant disordinal interaction was found for number of data requests and data matches. High ability (H) dyads requested more data than H individuals. L dyads received fewer data matches than L individuals and HL dyads.

A significant disordinal interaction for total time was observed. H individuals spent less time in the problem space than H dyads. L individuals spent more time than dyads.

Significant main effects for mental ability were found for proportion of positive and negative information presented and time spent reading neutral information. L subjects received fewer instances of positive information, more neutral information and spent more time reading neutral information than HL subjects or H subjects. H subjects received more positive information, less neutral information, and spent less time reading the neutral information.

Glaser encourages the blending of psychological theory and educational practice. Specifically, this study provides insight into the process of data search and utilization by individuals and dyads under conditions of interactive feedback.

CONCURRENT SESSIONS III

Session IIID - Symposium

Presiding: Joseph D. Novak, Cornell University, Ithaca, New York 14853.

"Ausubelian and Piagetian Models for Science Education Research"

Joseph D. Novak, Cornell University, Ithaca, New York 14850.

Anthony Lawson, University of California at Berkeley, Berkeley, California 94720.

Warren Wollman, University of North Carolina at Greensboro, Greensboro, North Carolina.

Ronald Raven, State University of New York at Buffao, Buffalo, New York 14214.

CONCURRENT SESSIONS IV

Session IVA - Instruction

Presiding: Michael J. Padilla, University of Victoria, Victoria, British Columbia, Canada V8W 2Y2.

1. "Differential Learning Effects of Varied Numbers of Instructive Questions." William G. Holliday, University of Calgary, Calgary, Alberta, Canada.

2. "Effects of a Compensatory Reading Version of ISCS Level III Instructional Materials on Science Achievement." Charles E. Greene, Fitchburg Public Schools, Fitchburg, Massachusetts 01420, Michael Szabo and Lester Golub, The Pennsylvania State University, University Park, Pennsylvania 16802.

3. "The Effect of Intensive Instruction in Hypothesis Generation Upon Hypothesis Forming and Questioning Behaviors of Ninth Grade Students." Chris A. Pouler, Prince George's County Public Schools, Hyattsville, Maryland 20782 and Emmett Wright, University of Maryland, College Park, Maryland 20742.

4. "Predictions of Achievement and Success in ISCS - Level II." Thomas E. McDuffie, Saint Joseph's College, Philadelphia, Pennsylvania 19131.

DIFFERENTIAL LEARNING EFFECTS OF

VARIED NUMBERS OF INSTRUCTIVE QUESTIONS

William G. Holliday
University of Calgary
Calgary, Alberta, Canada

Flow diagrams (somewhat like those found in B.S.C.S. - 1973; Yellow Version, p. 556; and Green Version, p. 225) with instructive questions and under simulated classroom conditions can constitute an effective learning medium relative to a textual description, according to recent theory and research in science education. The present study is an extension of this previous work. Flow diagrams (i.e., pathways or cyclic schema) consist of sequential chains of verbal concepts in a condensed and "manageable" form. The following question was evaluated in this study: What is the learning effect of varied numbers of instructive questions accompanying the same flow diagram used in previous research? More precisely, high school biology students, who are asked questions covering all the critical verbal chains or who are induced to study thoroughly the same flow diagram without questions, should independently outperform those other students who are asked a reduced number of questions. In turn, these three experimental groups should independently outperform a placebo group. The instructive questions in the present study were each directed towards single links of verbal chains displayed in a flow diagram which described the biogeochemical cycles commonly taught in high school biology courses. Asking students instructive questions has long been cited as one of the best documented instructional techniques for increasing effective learning and retention. Classroom conditions in this study were simulated by telling students that their performance on the instructive questions and on the retention test questions would be transmitted to their biology teachers. High school biology students under typical experimental conditions are likely to have a relatively nonchalant attitude toward a learning and retention task unrelated to their course grade, rather than the more positive motivational set ordinarily inducible under classroom conditions.

Subjects were randomly assigned to a flow diagram plus 20 instructive questions; diagram plus no questions, a diagram plus five questions (i.e., randomly selected from the pool of 20 questions for each subject in this five-question group), and a placebo text describing animal behavior. Subsequently, all students were administered thirty multiple choice, prose form (i.e., "non-diagrammatic") posttest questions based on an operationally-defined synthesis and paraphrase of two or more instructive questions. The flow diagram consisted of colored stylized line drawings illustrating concrete stimuli, and logically positioned verbal labels of more technical stimuli joined by arrowed lines.

The scores from the posttest constituted the data. These data were generated by 175 high school students enrolled in an introductory biology course.

Three orthogonal comparisons of main effects indicated that the 20 question and no question treatments were independently more effective ($p < .05$) than the five-question treatment. In addition, the five-question treatment was more effective than a placebo. It was concluded that students, given a small sampling of instructive questions relevant to the criterion information found in such a flow diagram, are less likely to inspect those verbal chains not covered in the smaller sampling of questions.

Providing students with "too few" instructive questions can inhibit learning relative to a full-complement or a no-question treatment under the described experimental conditions.

EFFECTS OF A COMPENSATORY READING VERSION OF ISCS LEVEL III INSTRUCTIONAL MATERIALS ON SCIENCE ACHIEVEMENT

Charles E. Greene
Fitchburg Public Schools
Fitchburg, Massachusetts 01420

and

Michael Szabo
Lester Golub
The Pennsylvania State University
University Park, Pennsylvania 16802

This study investigated the idea that learning of selected science content is inhibited by a combination of less than optimum student reading ability and reading levels inappropriately high. It was predicated on a reading application of Salomon's compensatory model to science achievement.

Data linking reading ability to achievement were abstracted to science learning. Research suggests that instruction built around using audiotapes to compensate for poor reading ability can enhance science learning. The state of development of readability and syntactic formulae make possible development of a mechanism for reducing the readability levels of instructional materials to enable the below average reader to achieve more. It was hypothesized that a downward reading level modification would result in increased science achievement and treatment X reading ability interactions.

Two treatment groups studied the same materials (the Intermediate Science Curriculum Study Level III (ES) Program). The control group used the original Environmental Science (ES) materials while the experimental group was assigned the modified ES materials. The modified ES materials were reduced in reading level by two to three grade levels using a technique developed by the principal investigator.

The study used a 2 X 3 factorial design with two levels of treatment (original and modified reading levels) and three levels of reading ability (high, moderate, and low). ANOVA was used to test main and interaction affects upon the criterion of achievement in science.

Post hoc tests were performed to identify potential discrepancies in teacher time spent with students and student time during the study.

Subjects included 114 nonth grade students from a northeast industrial community. Matched pairs of students by reading ability (Gates-MacGinitie Reading Test) were randomly assigned to experimental or control groups.

The major criterion was a teacher-made science achievement test. Additional criterion data included student completion time and time spent by teacher with treatment groups.

High reading ability subjects scored significantly higher on the achievement test than did moderate reading ability subjects who in turn scored significantly higher than did the low reading ability subjects.

Achievement test scores for the experimental group were not significantly different from the control group. The difference in reading materials had no measurable effects on science achievement.

No differences in achievement between low or moderate ability students were observed across treatments. No evidence was obtained to show that modified reading material affects performance of low or moderate ability readers.

The hypothesis of equality between high reading ability experimental and control subjects was supported. Post hoc analyses of variance revealed no significant main or interaction effects for the criteria of student time to completion or amount of teacher time (experimenter bias).

The surprising results of this tightly controlled experiment raise powerful questions about the reading ability-science achievement controversy. The data suggest that compensatory reducing of reading levels of instructional materials does not impact on specific subject matter achievement. Specifically, they raise further questions about the relative importance of reading ability in a concrete and manipulative curriculum such as ISCS. It is suggested that the study be replicated in classrooms where little manipulation of materials occurs to enhance learning.

THE EFFECT OF INTENSIVE INSTRUCTION IN HYPOTHESIS GENERATION UPON HYPOTHESIS FORMING AND QUESTIONING BEHAVIORS OF NINTH GRADE STUDENTS

Chris A. Pouler
Prince George's County Public Schools
Hyattsville, Maryland 20782

and

Emmett Wright
University of Maryland
College Park, Maryland 20742

Because the development of acceptable hypothesis formation behavior is an essential part of science education, this study was designed to determine the effect of reinforcement and knowledge of criteria on the acquisition and application of such behavior by secondary students. Previous studies had indicated that hypothesis formation could be improved by group or individualized intensive instruction. To extend the findings of such work, this investigation was conducted to:

1. compare the effect of various hypothesis generation intensive instruction procedures on the ability of ninth grade students to generate written hypotheses, and
2. determine if students, who have received hypothesis generation intensive instruction in a setting free of peer interactions, exhibit a greater diversity of questions during a group discussion and greater written hypothesis generation behaviors after the discussion.

The subjects--selected from all the ninth grade intact science classes of a suburban junior high school--were assigned to either a control group or one of four intensive instruction groups. The procedures for each instructional group included:

1. watching the intensive instruction discrepant event until six acceptable hypotheses were written, and
2. individual discussion during which the investigator evaluated each of the six hypotheses by one of the following predetermined standards:
   a. differential reinforcement and criteria group--depending on the level of acceptability for each hypothesis, the student was both positively reinforced (good, very good, excellent) and told the criteria for good hypothesis formation,

b. undifferentiated reinforcement and criteria group--after each acceptable hypothesis, the student was only told the criteria for good hypothesis formation,

c. differentiated reinforcement only group--depending on the level of acceptability for each hypothesis, the student was positively reinforced (good, very good, excellent), and

d. undifferentiated reinforcement only group--had to generate six hypothesis (of any quality) each of which was accepted without positive reinforcement.

During the intensive instruction sessions, the subjects were shown discrepant events selected from the set of Inquiry Development Program Films. Following the sessions, all groups were shown two discrepant events and were requested to write hypotheses for one and questions for the other. Five days later each experimental group participated in a discussion where they observed another discrepant event and, then, voluntarily asked the investigator questions which were answered with yes or no.

The dependent variables were:

1. the quantity and quality of written hypotheses following intensive instruction,

2. the diversity of information search questions during the group discussion, and

3. the quantity and quality of written hypotheses after the discussion.

Major conclusions included the following:

1. Differentiated reinforcement is responsible for a higher quantity of written hypotheses after intensive instruction than the instruction method which involves no intensive instruction.

2. Differentiated reinforcement, criteria, or both conditions are responsible for a higher quality of written hypotheses, following intensive instruction, then undifferentiated reinforcement or no intensive instruction procedures.

3. Differentiated reinforcement only is responsible for a greater quantity of written hypotheses than no intensive instruction following the group discussion.

4. Criteria are responsible for a higher quality of written hypotheses, after the group discussion, than the instruction method of undifferentiated reinforcement or no intensive instruction.

5. And, in the presence of the group discussion, diversity of oral information search questions is not significantly improved by hypothesis generation intensive instruction.

PREDICTIONS OF ACHIEVEMENT AND SUCCESS IN ISCS - LEVEL II

Thomas E. McDuffie
Saint Joseph's College
Philadelphia, Pennsylvania 19131

Attribute-treatment interactions within the Intermediate Science Curriculum Study (ISCS) Level II were the study's focal points. The intent was to make and to verify predictions of achievement and success. Two questions summarize the work's direction.

1. Do differential treatment effects provide a basis for prediction?

2. How reliable are predictions based upon differential treatment effects?

On a practical, classroom level the study attempted to determine which students should not be enrolled in Level II. On a theoretical plane, the predictive abilities associated with differential treatment effects were explored. Two aspects of earlier research underlie the present study. First, highly significant differences existed between scores on the factors associated with high and low achievers, as well as successful and unsuccessful students. Second, ex post facto classification, utilizing step-wise discriminant analysis, correctly classified better than 85 percent of the top and bottom groups. Such differential treatment effects suggest a possible approach to prescriptive instruction. Students whose performance is predicted to be poor within the ISCS instructional mode can be counseled toward an alternative approach.

Based upon the discriminant function ability to classify, it was decided to utilize the mathematical expression as a means of generating predictions. Although statistically sophisticated, the research is fundamentally descriptive. Characteristics and functions associated with one group of Level II students were utilized to predict outcomes for the following year's students. Four stages were involved in the investigation.

1. Determining the top and bottom group based upon 1974-75 results; then, generating and testing the discriminant function.

2. Utilizing the discriminant function from one to generate probable group membership for each student anticipated to enroll in Level II in 1975-76.

3. Selecting the students predicted to be in top and bottom groups based upon probabilities.

4. Testing the accuracy of predictions as indicated by teacher ratings and past testing.

Students from a middle to upper-middle class suburban Philadelphia school district served as the data source. Information was obtained on 11 variables including: sex, verbal and mathematical aptitude, basic skills and knowledge, attitude toward science, achievement, and work style. Data from 376 students enrolled during the 1974-75 academic year were used to generate the discriminant function. The expression in turn was employed to generate probable group membership for 393 students in the following year's class. Individuals whose probable group membership was greater than 0.80 became the high (n = 91) or the low (n = 110) achievement groups as the outcomes dictated. Also generated were class-sized groups most likely to be high (n = 75) or low (n = 32) on both achievement and work style.

Contrasts between the predicted and actual achievement levels were upon a standardized Level II examination. Determining the reliability of success, non-success predictions involved teacher ratings. Two months into the school year, teachers judged students' overall compatibility with ISCS, indicating which students would be better suited to an alternative form of instruction.

A distillation of the study's achievement outcomes are presented in Tables I and II. Several features of the results are worthy of note. First, predictions of high achievement are significantly more reliable than those for low. Second, the discriminant function predicts achievement quite accurately. Third, when work style was

TABLE I

Outcomes of Predictions Based Upon Achievement

		PREDICTED	
		High	Low
ACTUAL	Top 1/3	72.3%	23.2%
	Middle 1/3	21.3%	37.5%
	Bottom 1/3	0.69%	39.3%

coupled with achievement predictions of non-successful students, i.e., those who would appear better suited toward another form of science instruction, predictions are substantially more correct.

TABLE II

Predicted vs Perceived Need for An Instructional Alternative

		PREDICTED	
		Alternative	ISCS
TEACHER	Alternative	71.9%	28.6%
	ISCS	21.9%	66.6%
	Neither	6.2%	4.8%

That differential treatment effects can be utilized to generate predictions seems clear. The reliability of predictions suggests that they are better suited for directing students toward, than away from, ISCS. However, when work style is joined with achievement, reliable predictions seem to follow.

Attribute-treatment interactions were taken a second step in this study. Differences between groups became a means of prediction, not an end. In essence, the results suggest the possibility of a viable avenue for prescriptive instruction.

CONCURRENT SESSIONS IV

Session IVB - Symposium

Presiding: Marcia C. Linn, University of California at Berkeley, Berkeley, California 94720

"A Free Choice Environment:

Advantages in the Classroom"

Marcia C. Linn, University of California at Berkeley, Berkeley, California 94720.

Herbert D. Thier, University of California at Berkeley, Berkeley, California 94720.

Warren Wollman, University of North Carolina, Greensboro, North Carolina 27412.

Jane E. Bowyer, Mills College, Oakland, California 94613.

Benjamin Chen, Ben Gurion University, Israel.

A FREE CHOICE ENVIRONMENT: ADVANTAGES IN THE CLASSROOM

Marcia C. Linn
University of California at Berkeley
Berkeley, California 94720

Herbert D. Thier
University of California at Berkeley
Berkeley, California 94720

Jane B. Bowyer
Mills College
Oakland, California 94613

Warren Wollman
University of North Carolina
Greensboro, North Carolina 27412

Benjamin Chen
Ben Gurion University
Israel

When students are allowed to choose what they want to do, a rather special situation emerges. Rather than diagnosing what would help the student learn, the teacher now takes the role of observing whether the student learns and what the student learns. Rather than feeling powerless in the classroom, the student feels some control over his or her environment. Rather than developing closed, didactic materials the curriculum developer focuses on interest and motivation. We would like to explore with you the reaction of students, teachers, and developers to a situation where students are invited to choose their own learning experiences. We will (1) describe the free choice environment and demonstrate an observational instrument which illustrates what happens, (2) discuss how the free choice environment fits into a regular classroom, (3) describe the motivational advantages to including free choice in an enrichment program, and (4) discuss how implementing a free choice environment for a small group of students can serve as an effective teacher training tool.

We have developed a set of 45 apparatus-based activities and a format for providing them which allows students to work under the supervision of a paraprofessional. In the free choice environment students choose the apparatus that interests them and decide what they want to do with the apparatus. We have found that students are more autonomous and creative when first given suggestions about how to use the apparatus and then invited to pursue their own investigations (Linn, Chen and Thier, 1976). We have recently developed a Super-8 film technique to characterize a 30 minute interaction on a 3 minute film. The advantages of this observational technique will be demonstrated.

A free choice situation was set up in three regular fifth-grade classrooms as an aid to instruction. In two classes free choice was combined with direct instruction in scientific reasoning (ability to name variables, recognize uncontrolled experiments, and control experiments). In the third class, free choice alone was presented. We found that free choice combined with instruction was more effective than free choice alone in teaching scientific

reasoning. More importantly, we found that observation during free choice helped us design effective instruction in an area that is frequently difficult to teach. We also hypothesized that free choice performed a very definite function in instruction. The next study illustrates this finding.

We hypothesized that free choice serves as a motivating factor for learning as well as an opportunity to try out one's own ideas and find out whether they work. Thus we set up an enrichment situation with three randomly assigned groups of sixth-grade students. Each group received six 15 minute sessions of direct instruction in scientific reasoning and twelve one hour sessions of free choice. We varied the order of these two procedures. One group had the two simultaneously, one group had instruction first, and one group had free choice first. We hypothesized that free choice followed by instruction would be the least effective, because students could not try out the concepts they learned by themselves. We hypothesized that students in the simultaneous condition would ignore the instruction, while students who received instruction first would be motivated to learn so that they would be prepared for the free choice. Results of the study will be discussed in terms of these hypotheses.

What can the teacher learn from the free choice environment? Preservice teachers served as free choice leaders for five students, two hours per week. Teachers' skill in observing students, asking students about their work (not telling them what to do) and recognizing students as individuals was assessed. The advantages of the free choice environment in alerting teachers to the role of individual differences in instruction will be discussed.

Linn, Marcia C., Benjamin Chen and Herbert D. Thier. "Teaching Children to Control Variables: Investigating a Free Choice Environment." Journal of Research in Science Teaching (In Press).

Session IVC - Paper Set: Teacher Control

Presiding: Jame[illegible]ell, St. John's University, Jamaic[illegible]York 11439.

1. "An Experimental Study of Teacher Control in Sixth Grade Science Classes: I. Background and Experimental Design." Robert K. Crocker, Roda P. Amaria and Glenn W. Clark, Memorial University of Newfoundland, St. John's, Newfoundland.

2. "An Experimental Study of Teacher Control in Sixth Grade Science Classes: II. Science Process Achievement." Roda P. Amaria, Helen Banfield, and Robert Crocker, Memorial University of Newfoundland, St. John's, Newfoundland.

3. "An Experimental Study of Teacher Control in Sixth Grade Science Classes: III. Pupil Preferences." Douglas B. Sheppard, Robert K. Crocker, and Roda P. Amaria, Memorial University of Newfoundland, St. John's, Newfoundland.

4. "An Experimental Study of Teacher Control in Sixth Grade Science Classes: IV. Pupil Perceptions." Glenn W. Clark, Gary Rumboldt, and Robert K. Crocker, Memorial University of Newfoundland, St. John's, Newfoundland.

5. "An Experimental Study of Teacher Control in Sixth Grade Science Classes: V. Summary Discussion." Robert K. Crocker, Memorial University of Newfoundland, St. John's, Newfoundland.

AN EXPERIMENTAL STUDY OF TEACHER CONTROL IN SIXTH GRADE SCIENCE CLASSES: I. BACKGROUND AND EXPERIMENTAL DESIGN

Robert K. Crocker
Roda P. Amaria
Glenn W. Clark
Memorial University of Newfoundland
St. John's Newfoundland

This paper, and succeeding ones in the set, reports preliminary results of an experimental study of teacher control in the setting of process-based elementary science activities. Experimental treatments were defined in terms of a number of teacher behaviors, essentially derived from a modified version of the concept of "pedagogical moves" as defined by Bellack and associates in their study of the language of the classroom. The influence of treatment as well as the interactive effects of treatment and selected pupil characteristic variables were investigated with respect to a number of classroom behavior, achievement, and pupil perception measures as dependent variables.

The rationale for the study of teacher control derives from Barker's behavior setting theory and from Bernstein's concept of strong and weak framing as a description of the range of options available to the pupil. One consequence of the behavior setting ideas is that an individual's performance is a function of the perceived goals of the setting. Classroom behavior might be expected to differ in high and low control settings because of possible differences in pupils' perceptions of the requirements of each environment. Grannis, following Bernstein, has proposed that a high control setting (strong framing) is incongruent with a requirement for high pupil-pupil interaction and that such incongruence should influence performance.

Hunt's elaboration of Lewin's $B = F(P,E)$ paradigm forms the basis for the study of interaction effects. In particular, the relative importance of pupil ability and personality variables in exhibiting interactions with treatments with respect to cognitive and noncognitive criterion variables is of interest. This interactive model may be seen as standing in contrast to main effects models such as that of Bernstein in that the interactive model does not propose that a particular treatment is universally applicable.

Ten grade 6 classes were exposed to an 18 week program consisting of activities from a process-based science curriculum. The program was divided into two nine-week treatments differing on a number of teacher behaviors related to the concept of control. Teaching was carried out by four teachers assigned to the project, to permit random assignment of teachers to classes and balanced

assignment of teachers to treatments (all teachers taught both treatments). The use of both treatments in all classes eliminated confounding due to unique class-treatment effects.

Each class was videotaped on three occasions during the term, yielding approximately eight taped sessions for each teacher. Transcripts of the tapes were coded using a category system derived from the system developed by Bellack. Observed teacher behaviors were used to monitor the application of the treatments and to investigate differences between teachers. Pupil behaviors are being coded and are to be used as dependent variables in a later phase of analysis.

Pupil characteristic variables included measures of ability (Lorge Thorndike Intelligence Test, Canadian Test of Basic Skills, Gates-McGintie Reading Test), personality (Junior Eysenck, Personality Inventory, Dependency Scale, Dominance Scale), self-concept of ability, locus of control (IAR), socioeconomic status (Blishen Scale), sociometric status, previous science experience, and attitudes towards school and science. Criterion measures consisted of paper-and-pencil tests of science process achievement, items from a pupil interview instrument (dealing with pupil perceptions of the activities), a rating scale for pupil perception of treatment from which was derived a measure of preference, and a number of pupil behavior categories from the classroom observation instrument.

AN EXPERIMENTAL STUDY OF TEACHER CONTROL IN SIXTH GRADE SCIENCE CLASSES: II. SCIENCE PROCESS ACHIEVEMENT

Roda P. Amaria
Helen Banfield
Robert Crocker
Memorial University of Newfoundland
St. John's, Newfoundland

The general rationale for the study has been described in the first paper of this set. The specific objective of this aspect of the study was to develop measures of achievement in the science process of measuring, controlling variables, and interpreting data and to compare experimental treatments and explore possible interactions between treatment and pupil characteristics with respect to pupil performance on these measures.

Three paper-and-pencil process instruments were developed for use as pretest and first and second round posttests respectively. The pretest consisted of process-related items not specific to the content of the lesson to be taught, while each posttest was made up of both content-specific and more general process items. All tests were based on the AAAS science process hierarchy and the associated competency measures, and the AAAS Science Process Instrument (Experimental Edition), with modifications to accommodate group administration.

The experimental design was as described in the first paper. Process tests were administered during the first week of the study and at the end of each treatment period. Data were analyzed using analysis of variance in a two-way repeated measures design to permit the assessment of interactions and to avoid confounding of treatment and class effects.

The analysis of treatment main effects showed no significant differences. A number of significant interaction effects did, however, occur. The interactions were somewhat stronger for pupils who were exposed to the low control treatment followed by the high control treatment than for those for whom the treatments were applied in the reverse sequence. The directions of the interactions were such as to suggest that the sequence of application of the treatments may be more important than the treatments themselves in influencing pupils with specific characteristics. The results were further complicated by the presence of strong treatment-class interactions, suggesting that some unique characteristics of particular classes (perhaps previous exposure to the type of science experiences used or to particularly low or high control by the regular class teacher) exerted a significant influence on performance.

AN EXPERIMENTAL STUDY OF TEACHER CONTROL IN SIXTH GRADE SCIENCE CLASSES:

III. PUPIL PREFERENCES

Douglas B. Sheppard
Robert K. Crocker
Roda P. Amaria
Memorial University of Newfoundland
St. John's, Newfoundland

The purpose of this part of the study was to investigate treatment effects and trait-treatment interactions using a measure of pupil attitude towards treatments as the dependent variable. The general hypothesis pertained to interaction effects in that it was expected that, independently of any treatment influences on achievement, certain pupil characteristics, particularly those related to personality, would influence pupil liking for the experimental treatments. The basis for this expectation lies in the nature of the teacher control variables as increasing or restricting pupil freedom to carry out the classroom activities in a manner of their own choosing. In addition, the teacher control variables were such as to increase or decrease the amount of possible pupil-pupil interaction.

Although all subjects were exposed to both treatments, it was not possible to use a direct measure of preference because it was thought that pupils would be incapable of directly comparing the treatments on the specific control variables of interest and, more generally, because the length of each treatment made it unlikely that subjects would recall the details of the first treatment by the time the second treatment had ended. It was therefore necessary to develop a measure of attitude towards each treatment separately. A 22 item scale was therefore developed, consisting of one positively and one negatively worded item on each of the control variables used in differentiating the treatments. When scored in the context of a specific treatment, the total score on this instrument could be interpreted in terms of degree to which the pupil liked that treatment or a treatment more extreme than that being assessed (i.e. for each item, a pupil could be scored on liking more control, less control, or neutral with respect to either treatment).

Preliminary analysis of the data has been based on cross tabulation of three score categories (high, medium, and low) by levels on each of the pupil characteristics of interest. Separate analyses were carried out for the two treatment rounds. Although this resulted in confounding of treatments with unique class effects for each round, this confounding was balanced by considering results as significant only if they were consistent over both rounds.

The preliminary analysis has suggested the existence of highly significant treatment main effects for both rounds, in such a direction to indicate that pupils show a distinct preference for low teacher control. This result, however, must be interpreted in the light of a relatively large number of interaction effects which suggest that the treatment effect is more pronounced for certain types of pupils than for others. That is, the interactions tended to be ordinal rather than disordinal in nature. More specifically, pupils of high ability, more outgoing and dominant personalities, and high self-concept tended to show stronger preference for low control than others. The fact that these clusters of variables were generally uncorrelated indicates that the observed interactions are relatively independent of each other.

AN EXPERIMENTAL STUDY OF TEACHER CONTROL IN SIXTH GRADE SCIENCE CLASSES:

IV. PUPIL PERCEPTIONS

Glenn W. Clark
Gary Rumboldt
Robert K. Crocker
Memorial University of Newfoundland
St. John's, Newfoundland

The general hypothesis under investigation in this phase of the study was that pupils would tend to perceive the high control treatment in different terms from the low control treatment. More specifically, it was expected that pupils under high control would perceive the activities more in procedural terms and in terms of teacher requirements and directions, while those in low control would hold perceptions that were oriented towards the process nature of the activities and towards freedom to pursue the activities in ways other than that defined by the teacher. As in other aspects of the study, it was also expected that perceptions within a treatment would be influenced by pupil characteristics.

A second objective of this part of the study was to investigate the relationships between pairs of pupils assigned to work together during the activities. The hypothesis here related less to treatments than to the issue of the dynamics of the pupil-pair group structure and the matching of pupils in such groups.

Accordingly, the design of the study required the development and application of a pupil interview schedule designed to yield data on pupil perceptions of the purposes of the activities, of the degree of teacher control employed, and of relationships between members of the pupil-pairs which constituted the basic grouping arrangement in the activities. Pupil interviews were chosen as an alternative to other techniques such as rating scales or checklists in order to allow for open-ended responses and to permit probing of the reasons for specific pupil responses.

The interview schedule was designed to provide a standard format whereby interviewers could ask questions about 1) whether the pupils perceived the activities in process, content, procedural, or other terms, 2) how the pupils perceived the frequency, clarity, and sufficiency of teacher directions for the conduct of the activities, 3) pupil perceptions of the amount of freedom available in carrying out the activities, and 4) the pupil's relationship with his partner. In general, the interviewer was required to categorize responses in terms of a set of predefined categories, while allowing for the possibilities of responses that did not conform to these categories. For most questions, pupils were asked why they gave a particular response.

On four occasions throughout the experimental sequence, eight pupils (four pairs) were selected as interview subjects. The interviews took place immediately following a science activity, and questions were framed in the context of that activity. During the first round, interviews were recorded on audiotape for discussion among interviewers and to permit reliability checks.

The preliminary results given here are based on cross-tabulations of the item responses by treatment and various pupil characteristics. The chi-square statistic has been used in tests of significance.

Responses to the several questions pertaining to the nature of the activities were classified as procedural, content, process, and other. Surprisingly, few pupils in either treatment perceived the activities as process-oriented. However, pupils in high control had a greater tendency to perceive the activities in procedural terms while those in low control perceived the activities more in content terms.

Responses to items concerning teacher directions, correctness of procedures, importance of following procedures, and so on, generally showed no discrimination between treatments. Responses were typically highly positively toned, suggesting that a positive response set may have been operating to a sufficient degree to mask any treatment-differences that might have existed.

Items on pupil-pupil relationships also generally showed no treatment differences. In this case, however, such differences were of less interest than the nature of the responses themselves and the comparison of responses for groups whose members were "matched" or "unmatched" with respect to particular characteristics. This latter aspect of the analysis is as yet incomplete. The results that are available indicate that, in general, pupils can work well together, at least by their own admission, and that pupils tend to give their partners much of the credit for the performance of the pair. Pupils tended to cite friendship and willingness to share as reasons for being compatible with partners.

AN EXPERIMENTAL STUDY OF TEACHER CONTROL IN SIXTH GRADE SCIENCE CLASSES:

V. SUMMARY DISCUSSION

Robert K. Crocker
Memorial University of Newfoundland
St. John's, Newfoundland

The general purpose of the study was to investigate variations in teacher control of pupil activities in science classes, and the interactions of these variations with pupil characteristics, with respect to pupil achievement of science process skills and pupil perceptions and preferences relative to the experimental treatments. In designing the study, an attempt was made to reduce the usual sources of confounding when classes are used as experimental units by balanced assignment of treatments and teachers to classes. With each class receiving both treatments, it was possible to control for initial class differences in making comparisons between treatments.

The preliminary results reported in the preceding papers indicate that no overall treatment effects existed with respect to the achievement criterion but that such differences did occur for the preference criterion. A number of interaction effects occurred for achievement, but apparent reversals of these effects when different sequences of application of the treatments were examined suggested that the direction of shift of treatments may be more significant than treatments themselves. Somewhat stronger and more consistent interactions occurred for the preference criterion.

From a theoretical standpoint, the results lend support to the validity of an interactive model in teaching strategy studies. It also appears that the interactive model is more valid in the non-cognitive area than in the cognitive domain. Certainly if the maintenance of positive pupil views towards the learning environment is regarded as a desirable objective, than a model of the teaching process which permits variation in teacher control as a function of pupil characteristics is required.

Most of the major elementary science curriculums have emphasized, in some form, the process component of science. Most such curriculums are also committed to the provision of first hand experiences in the learning of scientific processes and operate from a fairly common base of activities. In spite of this, considerable variation exists in the degree of teacher control of pupil activities associated with these curriculums. The number and strength of interaction effects found in this study suggests that a main effects approach to teacher control (i.e. where either high or low control is adopted for all pupils) is inappropriate.

A major limitation of the study lies in the fact that the experimental treatments did not provide for variations in what might be termed lesson structure. That is, pupil options may be either increased or decreased in the classroom not only by varying the relative frequency of teacher moves as in the present study but also by varying lesson objectives, apparatus, time, and so on. Since the definition of control as used in this study represents only one aspect of Bernstein's framing concept, it cannot be inferred that a main effects model such as Bernstein's would not apply should other aspects of framing be varied.

CONCURRENT SESSIONS IV

Session IVD - Paper Set: College Science Teaching

Presiding: Robert J. Vanden Branden, Drake University, Des Moines, Iowa 50311.

1. "A Study of Sex-Bias in College Science Teaching." Linda J. Kelsey and Kathleen M. Filkins, University of Iowa, Iowa City, Iowa 52242.

2. "A Comparative Study of Student Behavior in Upper and Lower Level Laboratories in Five Science Disciplines." John E. Penick and James A. Shymansky, University of Iowa, Iowa City, Iowa 52242.

3. "The Role of Teaching Assistants in Upper and Lower Level Laboratories in Five Science Disciplines." James A. Shymansky, John E. Penick and William C. Kyle, University of Iowa, Iowa City, Iowa 52242.

4. "Some New Techniques in Collecting and Analyzing Classroom Behavior Data." Jay D. Wortman, John E. Penick and James A. Shymansky, University of Iowa, Iowa City, Iowa 52242.

A STUDY OF SEX-BIAS IN COLLEGE SCIENCE TEACHING

Linda J. Kelsey

and

Kathleen M. Filkins
University of Iowa
Iowa City, Iowa 52242

Sexism in the school curriculum has garnered a great deal of attention in the past few years. One of the prime targets of educator/sexist groups has been the area of science instruction, K-college. That women are in a small minority in the sciences is no secret; however, pinning the blame on this or that school practice prematurely can be risky, and lead to short-term, if not unsuccessful, remedies in the area of sex discrimination. Each potential source of sex discriminatory practice must be examined carefully before any final decisions can be made.

One such problem area is that of teacher bias in the classroom. Textbooks can be purged of sexist pictures and role stereotyping material, but such an effort stands little chance for success if the science instructor is oblivious to his/her own sex biases in the day-to-day classroom procedures.

This paper deals with the issue of instructor sex bias in both upper and lower level undergraduate science laboratory instruction. Observational data of instructor behavior in laboratory classes at a major mid-west university in the areas of physics, chemistry, botany, geology, and zoology collected by a team of four trained observers over a one-month period provide the data for this report. Among the data collected, a record of the sex of the instructor, the sex of each student with whom the instructor interacted during a laboratory session, the nature of the interaction, and the duration of the interaction were kept. This paper presents the results of these observations in descriptive and comparative form and explores some of the ramifications of current practices in college science laboratory classes.

Using an instrument designed at the University of Iowa specifically for science laboratories, more than 100 different laboratories were observed. Nearly 250,000 separate observations were made during the 200 hours of observation.

Much of the analysis was provided by a newly written computer program designed to isolate patterns of behavior which were occurring in the science laboratory.

Our initial descriptive analysis indicates that sex bias does exist in college science teaching and that this bias affects the type of interactions and their duration as well as who is being interacted with.

A COMPARATIVE STUDY OF STUDENT BEHAVIOR IN UPPER AND LOWER LEVEL LABORATORIES IN FIVE SCIENCE DISCIPLINES

John E. Penick

and

James A. Shymansky
University of Iowa
Iowa City, Iowa 52242

College science laboratories are usually thought of as providing students with opportunities for investigating; gaining skills, techniques and knowledge and, in essence, doing a lot of what scientists do. When we think of a student doing a laboratory activity we tend to think of the student busily observing, measuring, hypothesizing, testing, and so on. Unfortunately, this stereotype doesn't seem to be as prevalent as we would like.

To discover exactly what students were doing in their laboratories, four highly trained observers using specially designed instruments watched more than 3000 college science students in both freshman and upper level laboratories. These laboratories represented Botany, Chemistry, Geology, Physics, and Zoology.

The specific behaviors exhibited by these students were analyzed in terms of frequency and pattern and were compared among the various disciplines. This descriptive analysis provides a wealth of baseline data about laboratory activity -- a baseline that in many instances does not reflect much science.

We will follow our discussion of the findings of the study with specific suggestions to make science laboratories better reflect the nature of science while providing adequate preparation for future science courses.

THE ROLE OF TEACHING ASSISTANTS IN UPPER AND LOWER LEVEL LABORATORIES IN FIVE SCIENCE DISCIPLINES

James A. Shymansky
John E. Penick
William C. Kyle
University of Iowa
Iowa City, Iowa 52242

Most undergraduate science laboratories in large universities are taught by graduate teaching assistants. Typically, these assistants are recent graduates with little or no teaching experience, training or supervision. Our concern about the educational experience, being provided in college science laboratories prompted us to ask several questions. These questions included "What do laboratory instructors do in a laboratory?", "What differences in instructor behavior are evident among various science disciplines?" and "What differences are apparent between freshman laboratory instruction and upper level laboratory instruction?"

Searching for answers to these questions, we, along with four trained observers, spent more than 100 hours systematically observing teaching assistants in a number of laboratories in Botany, Chemistry, Geology, Physics, and Zoology.

Using an observation instrument especially designed for coding behaviors in science laboratories, we collected data on the occurrence of fifteen specific teacher behaviors, and the number and sex of student or students being interacted with.

Using a new computer program we were able to detect patterns of behavior as well as the frequency of specific behaviors. These patterns and frequencies were compared across laboratories in various science disciplines and between upper and lower level classes. In addition, data were blocked by several other teacher factors such as age, experience, education and degree objective.

Our analysis indicates that rather gross differences exist in science laboratory instruction at the college level. These differences are great enough that it is difficult to even say that some laboratories are even laboratories. In many instances we might be better off referring to the (non)teaching assistants.

Our paper will present our findings and some specific suggestions for improving the level of teaching in science laboratories.

SOME NEW TECHNIQUES IN COLLECTING AND ANALYZING CLASSROOM BEHAVIOR DATA

Jay D. Wortman
John E. Penick
James A. Shymansky
University of Iowa
Iowa City, Iowa 52242

Virtually no data have been collected regarding student and teacher behavior in college science laboratories. What few data have been collected have usually been less than systematic or gathered by means of nonspecific instruments.

Our initial question of "What really is happening in college science laboratories?" as well as a host of secondary questions dictated the development of new classroom assessment tools. These tools, referred to as SLIC (Science Laboratory Interaction Categories) coding student behavior and teacher behavior, allowed us to record the occurrence of a relatively large number of classroom behaviors as well as keeping track of sex bias, predilection toward specific persons or groups, and duration of interactions.

Data collection is but a trivial part of any classroom assessment when you consider the problems of using those data to build a valid picture of what was happening in that classroom. As a result, we have developed a rather complex computer program to analyze classroom behavior data.

This MACRO Analysis Program can isolate recurring patterns of behavior while maintaining a record of pattern time length, changes in interactions and frequency of patterns as well as several other variables. The program alone represents over 150 hours of development time. In addition we have developed programs designed to deal with selection of specific data sets and to demonstrate statistical independence of these data sets.

With the use of instruments such as SLIC and programs for MACRO analysis, much descriptive information can be learned about the functioning of students and teachers in classroom settings. This information can then be compared with descriptions of what ought to be happening. The end results of such a comparison is hopefully some decisions about what to do next.

AWARD LUNCHEON

Presiding: O. Roger Anderson, Columbia University, New York, New York 10027.

Speaker: Willard J. Jacobson, Columbia University, New York, New York 10027.

"NARST - A Golden Anniversary"

CONCURRENT SESSIONS V

Session VA - Learning Factors

Presiding: Frances Lawrenz, State University College at Buffalo, Buffalo, New York 14222.

1. "A Study of Risk Taking Characteristics of Learners and Science Achievement Resulting From Alternate Methods of Instruction." Larry F. Guthrie, Indiana University Northwest, Gary, Indiana 46408 and Gerald H. Gearhart, Kouts Elementary School, Valparaiso, Indiana 46383.

2. "An Analysis of the Relationship of Students' Self Concepts in Science to Their Mental Abilities, Sex, and Measures of Achievement in Science." Rodney L. Doran and Burt A. Sellers, State University of New York at Buffalo, Amherst, New York 14260.

3. "The Effectiveness of Generalizing Cues on Learning From Graphical Material." Paul D. Eggen, Donald Kauchak, and Sandra Kirk, University of North Florida, Jacksonville, Florida 32216.

4. "An Analysis of Cognitive Style Profiles and Related Science Achievement Among Secondary School Students." William R. Ogden, East Texas State University, Commerce, Texas 75428 and Patricia M. Brewster, Mesquite Intermediate School District, Mesquite, Texas 75149.

5. "An EEG Study: Hemispheric Brain Functioning of Six to Eight Year Old Children During Piagetian and Curriculum Tasks." R. Harter Kraft, The Ohio State University, Columbus, Ohio 43220.

A STUDY OF RISK TAKING CHARACTERISTICS OF LEARNERS AND SCIENCE ACHIEVEMENT RESULTING FROM ALTERNATE METHODS OF INSTRUCTION

Larry F. Guthrie
Indiana University Northwest
Gary, Indiana 46408

and

Gerald H. Gearhart
Kouts Elementary School
Valparaiso, Indiana 46383

The purpose of this project was to study a hypothesized relationship between the risk taking characteristics of learners and science achievement resulting from alternate methods of instruction.

The study involved 70 sixth-grade students heterogenously grouped into three classes. The three classes were taught identical subject matter from the ESS unit Mystery Powders using different methods of instruction. Class I was taught using an expository method which was highly structured and allowed no hands on experience. Class II was taught using a directed discovery method. This method was also highly structured but allowed considerable manipulation of materials. Class III was taught using a discovery method. This method was unstructured and allowed student directed manipulation of materials.

Each student then participated in a specially designed ring toss game to measure their individual risk taking characteristics. Students were classified as high, intermediate or low risk takers on the basis of these scores.

The hypothesis to be studied was that high risk takers' achievement would be greater than low risk takers as instruction moved from structured to unstructured. The null hypothesis, of course, was that no significant differences would appear.

Achievement data were collected from a pre and post test that included measurement of cognitive recall and application level items. A two way analysis of variance was used to compare the effects of treatments and risk on recall, application and total gain achievement. This comparison showed a relationship between risk and cognitive gain at the .047 level of significance. The relationship between treatment and total gain indicated an F ratio with a probability of .084.

Intermediate risk takers were found to have significantly higher cognitive recall gain scores. The directed discovery approach resulted in higher total gain. The interaction of intermediate risk characteristic and the directed approach resulted in

significantly greater gains at both the recall and application levels. These data suggest that there is a possible relationship between risk taking, method of instruction and gain achievement.

Although the data do not completely support the original hypothesis, there is much evidence that refinement and further study may lead to a clarification of these relationships. A refinement in the measurement of risk taking is suggested to increase the amount of variance of risk scores. The authors suggest that such refinements will support the relationship between risk taking, method of instruction and science achievement.

AN ANALYSIS OF THE RELATIONSHIP OF STUDENTS' SELF CONCEPTS IN SCIENCE TO THEIR MENTAL ABILITIES, SEX AND MEASURES OF ACHIEVEMENT IN SCIENCE

Rodney L. Doran

and

Burt A. Sellers
State University of New York at Buffalo
Amherst, New York 14260

The purpose of this study was to investigate the relationship between students' self concepts in science and their mental abilities, sex, and measures of achievement in science.

Based on theoretical constructs from the phenomenology of Combs and Snygg (1959), the client-centered framework of Rogers (1951), and the theoretical writings of Maslow (1954) and a review of relevant research, it was hypothesized that there would be a positive relationship between students' self concepts in science and their mental abilities and measures of achievement in science. It was further postulated that students' self concepts in science would be positively related to measured achievement in science when mental ability was partialled out. In addition, males were hypothesized to have higher self concepts in science than females.

The design of the study was to empirically validate the hypothesized relationship between students' self concept in science and the predictor variables mentioned earlier. In order to do this, the Self Concept in Science Scale (SCSS) was developed for this investigation to measure the self concept of students in science. The SCSS was developed utilizing a table of specification with two dimensions, (1) operations whereby students learn in the science classroom and (2) three components of self concept (identity, self-satisfaction, and behavior). Content validation was obtained via strict adherence to the table of specification and scrutiny by a panel of judges. Construct validation was ascertained by a comparison of scores from the SCSS with scores from the Tennessee Self Concept Scale, which was based on the same three self concept constructs. A pilot study was conducted to insure that the reading level was appropriate and to obtain an estimate of the scale's reliability (.82). Science achievement was measured by the Nelson Biology Test and the Test of Science Processes. The measure of the mental ability used was the Otis-Lennon Mental Ability Test, Advanced Form, J. Demographic data were obtained from guidance folders and a student questionnaire.

The instruments were administered to all members of a sophomore class of a central public high school located in an urban community of western New York. Students completing all instruments (N = 320) were used as subjects in this study.

An analysis of the data was made by multiple regression analyses and stepwise multiple regression analysis. Bivariate correlation coefficients were studied between individual dependent and independent variables.

The results supported the hypothesis that a relationship exists between students' self concepts in science and their mental abilities, sex, and measures of science achievement. Each of the bivariate correlations between the criterion variable of self concept in science and the predictor variables of mental ability, measured biology achievement, and measured process achievement were significant and positive ($\alpha = .05$). The bivariate correlation between self concept in science and sex was in the hypothesized direction (females having lower self concepts than males) but was not significant. The hypothesized relationship between students' self concept in science and their "differential achievement" (mental ability partialled out) and sex was not supported by the data obtained.

The major conclusion drawn from the results of the study is that students who are high achievers in both biology achievement and process achievement, and who have high mental ability will have the highest self concepts in science.

Combs, Arthur W. and Donald Snygg. Individual Behavior: A Perceptual Approach to Behavior. New York: Harper & Row, 1959.

Rogers, Carl. Client-Centered Therapy. Boston: Houghton Mifflin Company, 1951.

Maslow, Abraham H. Motivation and Personality. New York: Harper & Brothers, 1954.

THE EFFECTIVENESS OF GENERALIZING CUES ON LEARNING FROM GRAPHICAL MATERIAL

Paul D. Eggen
Donald Kauchak
Sandra Kirk
University of North Florida
Jacksonville, Florida 32216

The purpose of the study summarized in this paper was to investigate the effects of textual cues in the form of written generalizations on the learning of information from graphs.

The rationale for this study is described as follows:

The transmission of information in science texts is often accomplished through the use of graphs. However, research on the effectiveness of graphs (Vernon, 1946, 1950) in printed material has shown that graphs often add little to the understanding of textual material and may, under certain conditions (Vernon, 1951), have a deleterious effect on learning from textual material.

Research in the area of mathemagenic behaviors (Rothkopf, 1966, 1967; Frase, 1967, 1968; Bruning, 1968), has demonstrated that placing supplemental questions and statements (acting as mathemagenic inducing aids) in text often enhances the written material. In a study applying the mathemagenic research to learning from graphical material, Kauchak et. al (1975) found specific written cues to be superior to both general cues and a control condition in the acquisition of specific content from graphs. The study summarized here extends the previous study in investigating the effects of general cues on the learning of both specific and general information from graphs.

Subjects for this study were 59 college students enrolled in a general methods teacher education class. Students were randomly assigned to one of two experimental groups. Both groups read written materials describing five experiments on plant growth. The results of the experiments were presented in bar graphs but not in the written text. The treatment group was provided cues in the form of generalizations related to each of the experiments. The control group was merely asked to notice the results of the experiments. The information reported in the graphs was designed to be counter-intuitive to prevent students from correctly responding to the post test from memory or experience.

A post test of six questions was administered after the presentation of each graph. The post test consisted of questions designed to test 1) knowledge of the major results of the experiments; 2) incidental information; and 3) knowledge of patterns. The post test reliability using Kuder-Richardson 21 was .84. The results were analyzed using a one way analysis of variance comparing control and experimental groups.

The results showed that the control group scored significantly better than the treatment group on total score ($p < .001$), knowledge of major results ($p < .001$), and incidental information ($p < .05$).

Further analysis investigated whether a training effect existed for each of the successive post tests. Analysis of variance showed significant differences between successive tests on total score ($p < .01$), incidental questions ($p < .01$), and pattern questions ($p < .05$).

The results of this study are interesting for several reasons. The significant differences between successive administrations of the post test showed that the questions were acting as cues to students, telling them where to look in succeeding graphs for important points. This can be considered to be a type of learning to learn phenomenon in which students use test-like events to cue themselves to the importantant aspects of a learning situation.

The second major finding of this study is that the type of supplementary cue is important in determining the effectiveness of that cue. The generalizing cues, rather than aiding learning, had a deleterious effect on learning, which resulted in scores which were significantly lower than control scores. One explanation for this result is that responding to the generalizing cues, rather than producing general inspection behaviors in students instead, put such a strain on them that they were prevented from learning the material at hand. It should be noted that the subjects in the study had received no prior instruction in generalizing or judging the validity of generalizations. Such training could have a decided effect on the effectiveness of generalizing cues. The results show that cues are most effective when matched directly to the criterion questions.

Bruning, R. H. "Effects of Review and Testlike Events Within the Learning of Prose Materials." Journal of Educational Psychology, 59:16-19, 1968.

Frase, L. T. "Effects of Question, Location, Pacing, and Mode of Retention of Prose Material." Journal of Educational Psychology, 59:244-249, 1968.

Frase, L. T. "Learning from Prose Material: Length of Passage, Knowledge of Results, and Position of Questions." Journal of Educational Psychology, 58:266-272, 1967.

Kauchak, D., P. Eggen, and S. Kirk. "The Effect of Written Cues on the Learning of Graphical Material." Paper presented at the National Association for Research in Science Teaching, San Francisco, April, 1976.

Rothkopf, C. Z. "Learning from Written Instructive Materials: An Exploration of the Control of Inspection Behavior by Testlike Events." American Educational Research Journal, 3:241-250, 1966.

Rothkopf, C. Z. and E. Bisbicos. "Selective Facilitative Effects of Interspersed Questions on Learning from Written Materials." Journal of Educational Psychology, 58:56-61, 1967.

Vernon, M. D. "Learning from Graphical Material." British Journal of Psychology, 36:145-157, 1946.

Vernon, M. D. "Learning and Understanding." Quarterly Journal of Experimental Psychology, 3:10-23, 1951.

AN ANALYSIS OF COGNITIVE STYLE PROFILES AND RELATED SCIENCE ACHIEVEMENT AMONG SECONDARY SCHOOL STUDENTS

William R. Ogden
East Texas State University
Commerce, Texas 75428

and

Patricia M. Brewster
Mesquite Intermediate School District
Mesquite, Texas 75149

The major purpose of this study was to identify cognitive styles for successful and unsuccessful science students at the secondary level which might have implications for the secondary science curriculum. Additional purposes were to identify common and unique elements in these composite cognitive styles and to substantiate the description of the groups of successful and unsuccessful science students according to the variables: science achievement, knowledge of the processes of science, and attitude toward science. Sexual differences were also considered.

The sample included 351 tenth, eleventh, and twelfth grade students. The sample was randomly selected, but reflected the proportional representation of each grade in the parent population. It included 196 males and 155 females. Each subject was administered the Test of Academic Progress: Science, Form 1, the Wisconsin Inventory of Science Processes, and an adaptation of the Hartman Science Attitude Test. The cognitive style of each individual was mapped using the Cognitive Style Mapping Booklet. A group of 83 successful and a group of 91 unsuccessful science students were identified according to science achievement. Data for these students were analyzed employing analysis of variance, with the Tukey *t*-test, chi square, and Pearson's product moment correlation with Fisher's *t*-test. Definitional criteria were employed to identify composite cognitive styles and common elements and unique elements of these cognitive styles.

The major finding of the study was that there was a composite cognitive style for successful and unsuccessful science students at the secondary level which might have implications for the secondary science curriculum. Other findings of the study included the identification of composite cognitive styles, and elements common and unique to these cognitive styles for male and female successful and unsuccessful science students at different grade levels in the secondary school. Significant differences were

identified for the following:

1. Achievement in science for successful and unsuccessful science students.

2. Cognitive styles of successful and unsuccessful science students at the secondary level.

3. Cognitive styles of male and female successful and unsuccessful science students at the secondary level.

4. Cognitive styles of successful and unsuccessful science students at different grade levels in the secondary school.

5. Knowledge of the processes of science for successful and unsuccessful science students at the secondary level.

6. Knowledge of the processes of science for male and female successful and unsuccessful science students at the secondary level.

7. Attitude toward science for successful and unsuccessful science students at the secondary level.

8. Attitude toward science for male and female successful and unsuccessful science students at the secondary level.

9. Attitude toward science for successful and unsuccessful science students at different grade levels in the secondary school.

AN EEG STUDY: HEMISPHERIC BRAIN FUNCTIONING OF SIX TO EIGHT YEAR OLD CHILDREN DURING PIAGETIAN AND CURRICULUM TASKS

R. Harter Kraft
The Ohio State University
Columbus, Ohio 43220

Recent evidence that the left cerebral hemisphere is the verbal analytical specialist with a sequential-processing cognitive mode and the right cerebral hemisphere is the visuo-spatial gestalt specialist with a holistic-processing cognitive mode suggests that various curriculum tasks require integrative hemispheric processing. This study focused upon investigation of lateral asymmetry in children's hemispheric functioning during performance of Piagetian and curriculum related tasks.

Eighteen children ages six to eight years were identified and electroencephalograms were recorded from parietal leads (P3-P4) while each performed a battery of tasks: Piagetian conservation tasks (Conservation of Substance and Area), Piagetian temporal tasks (Waterflow and Dollrace), spatial tasks (WISC Block Design and Rotated Forms), curriculum related tasks (reading, syllogistic logic and mental arithmetic).

Statistical evaluation which included analysis of variance, Pearson r, and discriminant analysis yielded the following results ($p < .05$).

1. There was significantly greater right hemispheric activity measured during the stimuli period and significantly greater left hemispheric activity measured during the response period of Piagetian and reading tasks.

2. High performers on the reading comprehension questions and the Dollrace task had significantly greater right hemispheric activity than the low performers during the response period. The same pattern was observed between the high and low performers on the Conservation of Substance task at ($p = .16$).

3. There were significant positive intercorrelations between the hemispheric brain waves of a) the stimuli periods of Piagetian and reading tasks, b) the response periods of Piagetian and reading tasks and those measured during verbal, logical, mathematical and block design tasks and c) the responses measured during performance of parallel forms of reading, mathematical and spatial tasks.

4. There were significantly different group patterns of asymmetrical hemispheric functioning between children having different sex and hand-eye preference.

On the basis of these findings it was concluded that tasks with visuo-spatial components during the stimulus (or encoding) period and verbal-logical components during the response (or decoding) period tended to elicit right hemispheric activity during the encoding and left hemispheric activity during the decoding. However, high performers on these tasks tended to show a greater proportion of right hemispheric activity during the decoding period than low performers indicating that the verbal left hemisphere of the high performers utilized greater ability to tap the visuo-spatial right hemisphere's knowledge about the stimulus. Therefore, the investigator suggests that Piagetian tasks are behavioral measurements of interhemispheric communication and selective inhibition and further, that the ontogeny of Piagetian stages is a behavioral index of maturing neural fibres (between the left and right cerebral hemispheres and from the reticular activating system to the two hemispheres) which facilitate these processes.

Implications from this study include: 1) differential instructional strategies for children based on their sex, hand-eye preference and level of cognitive development and 2) selection of instructional strategies which facilitate integration of right and left hemispheric modalities such as manipulation of concrete objects, imagery, audio-visual aids and mnemoticc devices.

CONCURRENT SESSIONS V

Session VB - Award Papers

Presiding: Calvin W. Gale, Michigan Technological University, Houghton, Michigan 49931

and

John T. Wilson, University of Iowa, Iowa City, Iowa 52242.

CONCURRENT SESSIONS V

Session VC - Paper Set: Piaget's Grouping Model

Presiding: Gerald L. Abegg, Boston University, Boston, Massachusetts 02215.

1. "Piaget's Grouping Model and its Relevance to Research in Science Education." Darrell G. Phillips, The University of Iowa, Iowa City, Iowa 52242.

2. "An Investigation of the Development of Six Topological Piagetian Groupings in Pre-School, Kindergarten, and Second Grade Children." Herbert G. Cohen, Arizona State University, Tempe, Arizona 85281.

3. "An Investigation of Piaget's Groupings: Seriation and Projective Space." Gordon E. Odegaard, Mount Vernon High School, Mount Vernon, Washington 98273.

4. "Six Major Logical Groupings of Concrete Operational Thought." David L. Camp, Bowman-Gray School of Medicine, Winston-Salem, North Carolina 27103.

5. "The Performance of Secondary School Students on Piaget-Type Tasks of Projective and Euclidean Space." Carole J. Reesink, The University of Iowa, Iowa City, Iowa 52242.

PIAGET'S GROUPING MODEL AND ITS RELEVANCE TO RESEARCH IN SCIENCE EDUCATION

Darrell G. Phillips
The University of Iowa
Iowa City, Iowa 52242

This paper serves to present briefly Piaget's logical and infralogical grouping structures and to acquaint the reader with the series of studies completed, ongoing, and anticipated at this Science Education Center.

In addition, the significance of this model for Science Education is pointed out and a framework is provided for the research papers that follow.

AN INVESTIGATION OF THE DEVELOPMENT OF SIX TOPOLOGICAL PIAGETIAN GROUPINGS IN PRE-SCHOOL KINDERGARTEN AND SECOND GRADE CHILDREN

Herbert G. Cohen
Arizona State University
Tempe, Arizona 85281

This study examined whether or not a hierarchical relationship existed among six Piagetian-type tasks designed to examine associated topological groupings. Additional aspects investigated were: the possibility of parallel development between certain of the logical and topological concepts; relationships between task performance and grade level and between task performance and sex.

One hundred subjects were individually interviewed using seven Piagetian-type tasks. The data analysis indicated that the spatial tasks did form a unidimensional scale and that significant differences did exist between task performance and grade level and between the task performance of males and females on certain tasks.

AN INVESTIGATION OF PIAGET'S GROUPINGS:

SERIATION AND PROJECTIVE SPACE

Gordon E. Odegaard
Mount Vernon High School
Mount Vernon, Washington 98273

The primary feature of this research was to determine whether or not an ordered relationship existed between performance on six Piagetian-type tasks. Additional aspects researched: What proportion of children at each level performed successfully on each task? Was there a relationship between task performance of males and females?

The tasks were individually administered to a stratified random sample of 108 students. Scalogram analysis indicated the task scores formed a unidimensional scale. Significant differences were found between tasks scores and age level and were not found between task performance of males and females except for one projective task.

SIX MAJOR LOGICAL GROUPINGS OF

CONCRETE OPERATIONAL THOUGHT

David L. Camp
Bowman-Gray School of Medicine
Winston-Salem, North Carolina 27103

The primary question addressed by this study was to investigate whether or not the scores on six Piagetian-type tasks formed a unidimensional scale. One hundred and two elementary school children in grades one, two, and three were administered each of the six tasks during individual interview sessions. These tasks correspond to six of the logical groupings of concrete operational thought. The analysis used indicated that the six tasks did form a unidimensional scale. The resulting ordered scale for these tasks was consistent with the scale which could be constructed on a theoretical basis.

THE PERFORMANCE OF SECONDARY SCHOOL STUDENTS ON PIAGET-TYPE TASKS OF PROJECTIVE AND EUCLIDEAN SPACE

Carole J. Reesink
The University of Iowa
Iowa City, Iowa 52242

This study involved the use of Piagetian-type tasks in the area of projective and Euclidean space. Four tasks covering these two areas were administered to 99 junior and senior high school students. These tasks involved: volumes of revolution (locus problem), geometric sections of several solids, folding patterns of several solids, and projection of shadows of both planar and solid objects. Age was found to be a significant factor in the performance on these tasks while sex differences were found on three out of the four tasks. Scalogram analysis indicated that the four tasks did form a unidimensional scale.

CONCURRENT SESSIONS V

Session VD - Symposium: Teacher Preparation

Presiding: Doris Trojcak, University of Missouri, St. Louis, Missouri 63121

"Measuring Effectiveness in Science Teacher Preparation Programs"

1. "Using Learner Performance to Measure Science Teacher Effectiveness." James R. Okey and William R. Zeitler, University of Georgia, Athens, Georgia 30602.

2. "Evaluating Teachers Using Teacher Performance." David P. Butts and William R. Capie, University of Georgia, Athens, Georgia 30602.

3. "Establishing Links Between Teacher Behavior and Learner Outcomes." David H. May and Joseph P. Riley, University of Georgia, Athens, Georgia 30602.

4. "Evaluating Science Teacher Preparation Programs by Assessing Teachers and Pupils." Russell H. Yeany, Jr., University of Georgia, Athens, Georgia 30602.

Reactors: Carl Berger, University of Michigan, Ann Arbor, Michigan 48109.

Howard L. Jones, University of Houston, Houston, Texas 77004.

USING LEARNER PERFORMANCE TO MEASURE SCIENCE TEACHER EFFECTIVENESS

James R. Okey

and

William R. Zeitler
University of Georgia
Athens, Georgia 30602

Since the purpose of teaching is to influence learning, the use of learner achievement and activity as a measure of teaching effectiveness is a logical one. Learners, schools, teaching methods, and curricula are sufficiently different, however, that there are numerous problems associated with using pupil data to evaluate teachers. The intention in this paper will be first to present a rationale for using learner outcomes as the primary indicator of teacher effectiveness and then to present specific procedures for collecting different kinds of pupil data to use in this process. Attention will be given to the problems of making reliable inferences about teacher effectiveness and to the role that fellow teachers play in establishing reasonable standards of teacher effectiveness.

EVALUATING TEACHERS USING TEACHER PERFORMANCE

David P. Butts

and

William R. Capie
University of Georgia
Athens, Georgia 30602

Since teaching is a set of actions planned to facilitate learning, it is desirable to compare the teaching performance with acceptable standards of teaching behavior. Teaching performance may be observed in contexts which differ in amount of structure and degree of realism. In any situation, techniques for describing teacher performance may be highly specific (e.g., Flanders) or more open (e.g., an anecdotal record). These descriptions of teacher performance are useful in diagnosing and planning subsequent training activities of preservice and inservice teachers.

In this paper, a rationale for using teaching performance as the best source for evaluating science teachers will be developed. Examples of observational techniques which vary in specificity will be analyzed in terms of their appropriateness for the amount of structure and/or the degree of realism.

ESTABLISHING LINKS BETWEEN TEACHER BEHAVIOR AND LEARNER OUTCOMES

David H. May

and

Joseph P. Riley
University of Georgia
Athens, Georgia 30602

The focus of this paper is on the complex interaction between teacher behavior and learner outcomes and the search for associational and causal relationships between them. Both the results from research conducted in this area and the methodology used to conduct the studies will be examined. Answers to the following questions will be reported. What links between teacher behavior and learner outcomes have been identified? Which of these links have been validated as to their efficacy in realizing instructional ends? What research methodology has been used and how effective has it been?

A critical evaluation will include a look at the generalizability of results to other populations and environments, as well as an assessment of future research needs and possibilities in further establishing links between teacher behavior and learner outcomes.

EVALUATING SCIENCE TEACHER PREPARATION PROGRAMS BY ASSESSING TEACHERS AND PUPILS

Russell H. Yeany, Jr.
University of Georgia
Athens, Georgia 30602

The instructional techniques and materials employed in science teacher preparation programs usually have the purpose of modifying the teachers' behavior in the classroom. These changes in teacher behavior are expected to improve pupil performance. Therefore, an assessment of the level of competency acquisition, application, and resultant pupil outcomes should be conducted to research the effectiveness of training, materials, or programs.

The paper presents a program evaluation scheme which provides an opportunity to assess the effectiveness of training program variations on a set of variables which range from pre-training performance of teachers to learning in pupils. The concept of using standardized gain scores will be offered as a means of comparing pupil learning when teachers are teaching toward different sets of objectives.

CONCURRENT SESSIONS VI

Session VIA - Symposium: Historical Studies

Presiding: Willard J. Jacobson, Columbia University, New York, New York 10027.

"Historical Studies in Science Education"

Willard J. Jacobson
Columbia University
New York, New York 10027

Leo E. Klopfer
University of Pittsburgh
Pittsburgh, Pennsylvania 15260

Roger W. Bybee
Carleton College
Northfield, Minnesota 55057

Alan J. McCormack
Peace Arch Plaza
Blaine, Washington 98230

HISTORICAL STUDIES IN SCIENCE EDUCATION

Willard J. Jacobson
Columbia University
New York, New York 10027

Leo E. Klopfer
University of Pittsburgh
Pittsburgh, Pennsylvania 15260

Roger W. Bybee
Carleton College
Northfield, Minnesota 55057

Alan J. McCormack
Peach Arch Plaza
Blaine, Washington 98230

Historical research is a very important, but much neglected, aspect of science education. Through historical research we can learn from our past experiences, and it is critical that we analyze and learn from the many kinds of ventures that have been undertaken in science education. While he who does not study history may not be doomed to repeat it, he is shackled by his lack of knowledge of what has been done in the past. This symposium is designed to stimulate further interest in History of Science Education studies, provide some insight into the problems that are often faced in historical studies, and help others who may wish to undertake historical studies in science education.

Three leading science education researchers who participated in the National Science Teachers Association's Bicentennial History of Science Education program and who have completed one or more historical studies in science education will discuss the major problems they faced in their studies in history of science education and offer their suggestions as to how others can overcome these problems. Each of the contributors will suggest further historical studies that they believe are important in science education. There will be interactions between symposium presenters, and questions and statements related to historical studies from the audience will be encouraged.

CONCURRENT SESSIONS VI

Session VIB - General Research

Presiding: Frederick P. De Luca, Iowa State University, Ames, Iowa 50011.

1. "The Immediate and Long Term Effect of Intensive Instruction Upon Basic Inquiry Skills." Emmett L. Wright, University of Maryland, College Park, Maryland 20742.

2. "Language Acquisition as a Byproduct of Science Instruction." Mary Ellen Quinn, Edgewood School District, San Antonio, Texas 78230 and Carolyn Kessler, University of Texas at San Antonio, San Antonio, Texas 78284.

3. "Psychomotor Abilities of Science and Non-Science High School Students." Rodney C. Doran, State University of New York at Buffalo, Amherst, New York 14260.

4. "The Effect of Topographic Cues on Mathemagenic Behavior in a Medical Terminology Course." Barbara B. Braverman and Judy Egelston Dodd, National Technical Institute for the Deaf, Rochester, New York 14623.

5. "The Development and Use of an Energy-Environment Assessment Instrument." Frank Fazio, Indiana University of Pennsylvania, Indiana, Pennsylvania 15701 and David L. Dunlop, University of Pittsburg at Johnstown, Johnstown, Pennsylvania 15905.

THE IMMEDIATE AND LONG TERM EFFECT OF INTENSIVE INSTRUCTION UPON BASIC INQUIRY SKILLS

Emmett L. Wright
University of Maryland
College Park, Maryland 20742

National Science Foundation junior high science curricula require students to utilize inquiry skills. Teachers often complain that inadequate student sophistication in analyzing problems and hypothesizing solutions has led to more structured activities.

Intensive instruction in observing (cue attendance) and hypothesizing* has been identified, with college Ss, as a technique useful in improving cue attendance, hypothesis generation and information search performance. (Particularly true when a film which presents complex and surprising stimuli is employed.)

In a two-step study, phase one explored the effects of intensively instructing individual ninth graders to either describe 75 details (group A) or synthesize 5 tenable hypotheses (group B) about a discrepant event, portrayed in a film loop, upon immediate performance in (1) the quantity of cues, (2) the quantity and quality of hypotheses, and (3) the quantity and diversity of information search. The control group received no intensive instruction.

Phase two, conducted 14 months later, again assessed the effects of the original instruction. Thus, both phases investigated identical questions: Were there differences between either experimental group and the control group; or differences between the two experimental groups?

Initially, 120 randomly selected Ss were equally divided between the 3 groups. In the follow-up, 54 of the original 60 Ss from one school were retested. (Permission not obtainable for retesting in the other school.) Immediately following intensive instruction in phase one and later in phase two, Ss individually viewed three film loops (different set for each phase) and described details, stated hypotheses, or asked questions.

For phase one, ANOVA, with a follow-up t test (both significant if $p < .05$), indicated Ss intensively instructed in cue attendance and hypothesis generation performed significantly better on all the dependent variables when compared to the control group except for the details observed by the hypothesis generation Ss; and both instructed groups performed equally on all dependent variables except the cue attendance group which observed a greater number of details.

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*No criteria, in terms of "quality," were discussed with the Ss.

ANOVA of phase two data determined Ss intensively instructed in: (1) cue attendance observed more details than either hypothesis generation or control Ss; (2) both hypothesis generation and cue attendance produced more hypotheses then the control group, but the hypothesis generation Ss produced a higher quality of hypotheses than either cue attendance or control Ss; and (3) cue attendance asked more questions with greater diversity than the hypothesis generation or control Ss. (No difference between the hypothesis generation and control Ss.)

It can be concluded that, initially, instruction in cue attendance was the most effective technique, since all five measures of basic inquiry skill improved significantly. Also, the time needed for criterion was less on the average for cue attendance. Similar conclusions can be drawn from the follow-up results, except that the cue attendance group did not produce higher quality hypotheses than did the control group (analysis did indicate a $p < .10$, close to significance).

Because functional inquiry skills are utilized by students on a continual basis in science courses, it would seem that instruction primarily in cue attendance, and possibly in hypothesis generation, could profitably become an appropriate activity for junior high school students; especially in light of the long term effects.

LANGUAGE ACQUISITION AS A BYPRODUCT OF SCIENCE INSTRUCTION

Mary Ellen Quinn
Edgewood School District
San Antonio, Texas 78230

and

Carolyn Kessler
University of Texas at San Antonio
San Antonio, Texas 78284

With increasing frequency, studies in the acquisition of language are moving from an emphasis on the acquisition of specific forms to investigations of the underlying cognitive processes governing the ability to acquire the systems of language. In ways not yet understood, some of the same cognitive mechanisms involved in learning science operate on the linguistic data that come to the child. Through hypothesis formation and hypothesis testing, the child constructs the set of rules accounting for the grammar of his language. As more refined hypotheses are generated, the child's grammar steadily progresses toward that of the adults. Studies demonstrating that children well into the school years are still in developmental stages of language acquisition closely parallel Piaget's theory of cognitive development (Tremaine, 1975).

The purpose of the study reported in this paper was to investigate the relationship between an inquiry approach to science instruct on and language development. And among investigators who have examined that relationship, Rowe (1970), McGlathery (1968), Ayers and Mason (1969) and Huff and Languis (1973) have all found that young children involved in an activity-based science course make considerable language gains.

Four classes of sixth grade children participated in the study, one control and one experimental group from each of two socio-economic levels. The treatment consisted of 12 science inquiry film sessions and 6 discussion sessions, each session 40 minutes in length. At the end of each science inquiry film session the students wrote as many hypotheses as they could in a rigorously controlled 12-minute period. The collected papers were then scored on two criteria: the Hypothesis Quality Scale developed by Quinn (1971) and the Syntactic Complexity Formula developed by Botet, Dawkins and Granowsky (1973).

Results of a statistical correlation study of the two sets of raw data, hypothesis quality scores and syntactic complexity, indicate high correlation between the two measures. That high correlation occurred in the treatment groups for both socio-economic levels. In other words, it was found that, as children improve in the cognitive process of hypothesizing, their language becomes syntactically more complex and this happens without any

direct effort to teach language. It can further be concluded that the link between the formation of scientific hypotheses and language development is cognitive development.

The implications for psychologists, science educators, linguists, science teachers, and language teachers are profound. Certainly the popular view that an individual who is very successful in science is generally not proficient in language-centered activities is challenged.

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McGlathery, G.E. "An Assessment of Science Achievement of Five and Six-Year-Old Students of Contrasting Socio-economic Backgrounds." ERIC Report ED 026 271, 1971.

Quinn, Mary Ellen. "Evaluation of a Method for Teaching Hypothesis Formation to Sixth Grade Children." Unpublished doctoral dissertation. Philadelphia: University of Pennsylvania, 1971.

Rowe, Mary Budd. "Science and Soul: Some Musings on Fate Control." Teachers College mimeographed report. New York: Columbia University, 1970.

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PSYCHOMOTOR ABILITIES OF SCIENCE AND NON-SCIENCE HIGH SCHOOL STUDENTS

Rodney C. Doran
State University of New York at Buffalo
Amherst, New York 14260

The laboratory has been an integral part of school and university science courses since the early 1900's. The rationale for laboratory experiences includes: (a) a portrayal of an accurate view of science, (b) encouragement of "learning by doing" and (c) stress on the practical and applicative aspects of science. Measures of the outcomes of school science program seldom include assessment of the laboratory experience, except through "paper and pencil" exams, "critical thinking" type tests, and less commonly, laboratory-based exams, often called "laboratory practicals." The correlation between these laboratory experiences and the other facets of science instruction is largely unknown. What instructional strategies optimize laboratory-oriented objectives? What student abilities are prerequisite to "functional learning" in laboratory situations? These and many other key questions remain unsolved.

The psychomotor domain was initially conceived by Bloom, Krathwohl, and associates in the middle 1950's. The corollary cognitive and affective domains were rapidly developed and have had a considerable effect on classroom instruction and educational research. The psychomotor domain has failed to experience such an evolution. Several persons have developed taxonomies of psychomotor objectives for specific fields; e.g. Simpson in home economics and Harrow in physical education.

The psychomotor domain is frequently described as having three components; (1) perceptual motor behavior, (2) fine motor skills, (3) gross physical tasks. Each of these is related to some degree with various aspects of science laboratory behavior; e.g. adjusting microscopes, handling pipettes, reading meters, and assembling apparatus.

This study was an attempt to investigate empirically whether these skills are prerequisites to achieving in science classes or whether they are outcomes of science courses and to determine how these skills relate to mental ability and student performance in science classes. The following null hypotheses were formulated to guide the statistical testing of our research questions:

I. There is no difference in psychomotor abilities between high school students enrolled in science courses and those not enrolled in science courses.

II. There is no difference in psychomotor abilities between high school students at grade levels 9, 10, 11, or 12.

III. There is no difference in psychomotor abilities between male and female students.

IV. There is no difference in psychomotor abilities between students enrolled in earth science, biology, chemistry, and physics.

V. There is no relationship among the several measures of psychomotor abilities for the student samples.

VI. There is no relationship between psychomotor abilities and mental ability for the student samples.

VII. There is no relationship between psychomotor abilities and past performance in science courses.

To investigate these hypotheses, data were collected during the last week of September and the first week of October, 1976, from over 200 high school students from an area school (some enrolled in science courses and some not) on several instruments. The Minnesota Paper Form Board Test assessed student skills in the perceptual area and the Stromberg Dexterity Test evaluated gross motor skills. The Bennett Mechanical Comprehension Test is composed of questions based on a variety of mechanical situations, such as wheelbarrows, levers, and pulleys. Student mental ability and past performance was obtained from the school files.

The data were analyzed via t-tests (Hyp. I and III), ANOVA (Hyp. IV), correlation coefficients (Hyp. V, VI, and VIII), with an alpha level of 0.05.

Hypothesis I was rejected for the Bennett (with "science" students achieving higher scores) but the data for the Minnesota and the Stromberg tests warranted acceptance of their null hypotheses. As Hypothesis II was largely redundant with IV, it was not tested separately. With respect to sex differences (Hyp. III), the data for the Bennett allowed us to reject the null hypothesis (with males scoring higher) but, once again, no significant differences were detected for the Minnesota and the Stromberg tests. For Hypothesis IV, significant differences were found on all three tests, with the more advanced students (i.e., chemistry and physics) outperforming their less sophisticated counterparts (i.e., biology and earth science). The data for Hypotheses V, VI, and VII were analyzed separately for each of the four science groups. Generally, the Bennett test scores were significantly related with IQ scores, last year's science grade, and the Minnesota scores (except for the earth science group). As was expected, IQ scores were related to last year's science grades, but were inconsistently related to scores on the Minnesota, Bennett, and Stromberg tests. Scores on the Minnesota test were not consistently related to grades in last year's science course. Because of the different nature of the Stromberg (manual dexterity), scores on it were generally not related (some negative correlations) with scores on the Minnesota and Bennett tests. The results generally support the contention that relationships exist between the psychomotor variables and past achievement in science and general mental ability.

THE EFFECT OF TOPOGRAPHIC CUES ON MATHEMAGENIC BEHAVIOR IN A MEDICAL TERMINOLOGY COURSE

Barbara B. Braverman

and

Judy Egelston Dodd
National Technical Institute for the Deaf
Rochester, New York 14623

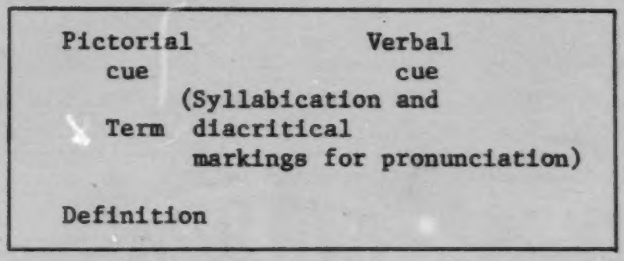
Post-secondary deaf students at National Technical Institute for the Deaf taking a major in medical records or medical laboratory technology have a required sequence of three medical terminology courses consisting of some 3000 primary and secondary vocabulary words. The words and their definitions must be mastered during this time. The verbal learning ability of deaf students has been explored (Stuckless, 1976) in an attempt to explain some of the difficulties faced in teaching/learning situations. The studies indicate that learning a vocabulary list could be a difficult task for deaf students, particularly if the words had low imagery or "signability."

The purpose of this study was to investigate design characteristics of instructional materials which would facilitate the verbal learning or mathemagenic behavior of deaf students. Verbal and pictorial cues have been shown to enhance learning of students; particularly students of low mental ability (Allen, 1975).

The choice of an appropriate physical stimulus designed to shape the mathemagenic behavior for a deaf learner presents a challenge. The risk of information overload in the initial presentation is a hazard with the alternatives of pictorial cue alone depriving students of the essential associative verbal reinforcement or the verbal cue alone depriving them of the visually interesting iconic mode which researchers and psychologists assume is dominant in the learning behavior of deaf people (Propp, 1972). For this study, the stimuli selected to shape the mathemagenic behavior were directed at the processing and segmentation responses of the learner (Wilson and Koran, 1976). They consisted of cues related to eight topographic codes representing the eight systems of the human body. The syntactic reference in segmentation is substituted in favor of the associative units composed of consistent prefixes, endings, etc., which are typical of biological terms. Processing includes the mental activities of categorization by systems of the human body and mnemonic associations which assist the memorization of terms and their definitions.

The following hypothesis was generated: Students presented vocabulary words with pictorial and verbal cues perform better on recall and retention tasks than do students receiving no cues or only verbal or pictorial cues.

A filmstrip was created with one term and its definition per frame. The maximum information load was carried on the frame as follows:



A pair of filters, attached to the projector, made it possible for the instructor to block either the term or the definition or show both together during instruction in class. The cue is the topographic code name for the system of the body to which the term is related.

The sixty terms covered in one unit (muscular-skeletal system) were randomly assigned to one of four groups as follows:

Group 1 - pictorial cue only

Group 2 - verbal cue only

Group 3 - both pictorial and verbal cues

Group 4 - control (no cues)

A counterbalanced design was employed. All 16 students viewed the filmstrip in class. Each student took a copy of the filmstrip and a projector to use in an independent drill and practice session until criterion level was reached (one-hundred percent correct). They recorded their responses for each trial run of the filmstrip in drill and practice on a frame-check sheet numbered to correspond to the frames in the filmstrip. The total number of errors for each trial was recorded on a graph of student performance.

Retention will be measured on the final exam for specific topographic codes as well as definition of a sample of terms from all four groups.

Individual student performance data will be available to assess error frequency over time spent in learning. Group performance in each of the three treatment and control conditions will be compared. Recall scores and retention scores from all four groups will be analyzed.

The design of media to facilitate learning of specific information has been of interest over the last several decades. An explanation of the interaction of expected performance (mathemagenic behavior) and media variables (cueing) will provide useful formative information for instructional medial producers and for science teachers as well. The difficulty of teaching basic technical vocabulary necessary for higher levels of learning required in science is always a challenge. Teaching vocabulary to deaf students who have particular difficulty with verbal learning presents a unique opportunity to search for media designs which make a difference in mathemagenic behavior.

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THE DEVELOPMENT AND USE OF AN ENERGY-ENVIRONMENT ASSESSMENT INSTRUMENT

Frank Fazio
Indiana University of Pennsylvania
Indiana, Pennsylvania 15701

and

David L. Dunlop
University of Pittsburgh at Johnstown
Johnstown, Pennsylvania 15905

The purpose of this investigation was to assess the general background knowledge of the college non-science major with respect to energy-environmental facts and concepts. It was hypothesized that in general, college students have a rather poor background in and lack an understanding of the current energy crises and the related environmental impacts of energy use. Since the hypothesis was later found to be true (accepted), the second purpose of this study was to develop a two-week six-lecture presentation on "Energy and the Environment" as part of a course in physical science for non-science majors.

It was hypothesized that the non-science majors would make significant gains in scores on the energy-environment assessment instrument as a result of the instruction.

A 20 item multiple choice test instrument was developed based upon the general facts, ideas, and concepts in the U. S. Energy Research and Development Administration (ERDA) Citizens' Workshop Program on Energy and the Environment. The instrument was titled Energy-Environment Quotient (E^2Q).

The content validity of the instrument was established and based upon the judgement of three college science educators. One of the authors is currently an active participant in ERDA's citizens workshop programs. The internal reliability using the Kuder-Richardson Formula was found to be 0.80.

The instrument was administered to four different sections of non-science majors at two universities in Western Pennsylvania. The scores were very low. They ranged between 6 and 8.20. A few high school groups in the area were also given the E^2Q instrument. The high school groups also had very low average scores (5-6.50).

The six-lecture presentation unit "Energy and the Environment" was developed and included such topics as fossil fuel uses, nuclear power generation, solar energy, conservation efforts, and environmental impacts, as well as other potential energy uses for the future. Slides, audio-tapes, and an Energy-Environment Simulator, a computer-like device that imitates the real world, was used in the presentation.

A pre-test and post-test design was used and the treatment group showed significant gain scores (0.01 level) on the E^2Q instrument.

Extensive item analysis of the E^2Q test instrument showed a need for some item revision of the instrument and possibly an extension of the number of items to 24 or 30.

The overall results of this study indicate a definite need to include Energy-Environment concepts in science courses for non-science majors. If we as science educators are to include relevancy in our science courses in order to enhance the scientific literacy of our future citizens, then relevant topics related to Energy-Environmental concepts are a must.

CONCURRENT SESSIONS VI

Session VIC - Teacher Education

Presiding: John P. Smith, University of Washington, Seattle, Washington 98195.

1. "An Investigation of Two Approaches for Education in Science of Preservice Elementary School Teachers." Donna L. Siemro, Governors State University, Park Forest South, Illinois 60466.

2. "Assessing the Difference of Teacher Behavior Among Three Elementary Science Curricula (ESS, SAPA, SCIS)." Naihua Chang and John T. Wilson, The University of Iowa, Iowa City, Iowa 52250.

3. "The Effects of Instruction in Science Process Skills on Reading Comprehension of Pre-Service and In-Service Elementary Teachers." Richard L. Campbell and Emma W. Rembert, Florida International University, Miami, Florida 33125.

4. "The Effects of Micro-Teaching on the Attitudes of Pre-Service Elementary Teachers Toward the Teaching of Science." Steven P. Bergel, South Country School District, Brookhaven, New York 11719 and H. Seymour Fowler, The Pennsylvania State University, University Park, Pennsylvania 16802.

AN INVESTIGATION OF TWO APPROACHES FOR EDUCATION IN SCIENCE OF PRESERVICE ELEMENTARY SCHOOL TEACHERS

Donna L. Siemro
Governors State University
Park Forest South, Illinois 60466

The purpose of this study was to determine if students in an elementary science methods course who had experienced different modes of university science instruction differed significantly on (1) understanding of the philosophy and processes of science, (2) attitudes toward science, and (3) beliefs about science teaching in the elementary grades.

In science education literature there is consensus that elementary teachers, in order to implement process-oriented science programs effectively, must have theoretical and experiential understanding of science processes as well as knowledge of science content (Karplus and Thier, 1966; Wood, 1970; A.A.A.S., 1970). Undergraduate science courses should provide future teachers with opportunities to become involved with science by carrying out investigations, thereby developing skill and confidence in using processes of inquiry.

The 224 subjects in the sample were enrolled in the elementary science methods course at the University of Iowa. Fifty-seven of the students had completed Science Foundations courses (Foundations students) as their Liberal Arts science requirement. These investigation-oriented courses were designed to familiarize future elementary school teachers with the processes of scientific inquiry. Instructors in the Foundations courses modeled the inquiry teaching methods taught in the science methods course. The remaining 167 students (non-Foundations students) had completed courses in specific science disciplines (e.g., zoology, chemistry) as their core science requirement. Experiences in these courses consisted mainly of lectures, laboratories, and discussion.

A major objective of the study was to determine if the two groups of students differed significantly on the three traits indicated above upon entering the methods course. The Wisconsin Inventory of Science Processes (WISP), the Silance Attitude Scale, and Beliefs About Science and Science Teaching were the criterion measures used to detect differences. The three tests were administered to all students upon entering the methods course.

A second objective of the study was to determine if significant differences existed in the degree to which attitude and belief systems of Foundations students and non-Foundations students changed during enrollment in the methods course. To determine if such differences existed, the Silance Scale and Beliefs About Science and Science Teaching were re-administered at the end of the methods course.

The t-test statistic was used to analyze the WISP total test mean scores. The Kolmogorov-Smirnov two-sample test was used to analyze the cumulative frequency distributions of the twelve WISP subscores. These analyses indicated that no significant differences (.05 level) existed between the two groups on understanding of the philosophy and processes of science as measured by this test upon enrollment in the methods course. This indicated that Foundations and non-Foundations students had comparable understanding of the philosophy and processes of science as measured by WISP upon entering the methods course.

Analysis of the Silance Scale pretest data using the Mann Whitney U test revealed that no significant differences in attitudes toward science existed between the two groups at the beginning of the methods course. It was concluded that the methods students' attitudes toward science as measured by the Silance Scale were independent of the type of university science instruction that the students had experienced.

Chi square analysis of Beliefs About Science and Science Teaching pretest data indicated that, for 27 of the 30 items, no significant differences in beliefs existed between the two groups at the beginning of the course. On the three items for which significant differences were detected, the beliefs of Foundations students were more consistent with philosophies expressed in the methods course than were the beliefs of non-Foundations students.

Pretest and posttest Silance Scale data for each group were analyzed using the Wilcoxon Matched Pairs Signed-Ranks test. These analyses indicated that the positive pretest attitudes toward science held by both groups did not change significantly during the methods course. It appears that students' attitudes toward science were relatively stable and were independent of the students' modes of university science training.

Analyses of pretest and posttest data from Beliefs About Science and Science Teaching using the Wilcoxon Matched Pairs Signed-Ranks test revealed that on 13 items, changes in opinion were significant for only non-Foundation students. This indicated that, for certain philosophies and teaching methods proposed in the methods course, Foundations students tended to withhold judgment or evaluate more critically than did non-Foundations students.

The study pointed out the need for development of criterion measures to detect subtle changes in students' attitudes and inquiry behaviors resulting from experiences in process-oriented science courses.

Furthermore, there is need for longitudinal studies to assess the status of teachers' attitudes and teaching behaviors as they progress through teacher education programs as well as after they enter the teaching profession.

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Karplus, R. and H. Thier. "Science Teaching is Becoming Literate!" Education Age, 2:40-45, 1966.

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ASSESSING THE DIFFERENCE OF TEACHER BEHAVIOR AMONG THREE ELEMENTARY SCIENCE CURRICULA (ESS, SAPA, SCIS)

Naihua Chang

and

John T. Wilson
The University of Iowa
Iowa City, Iowa 52240

ESS, SAPA, and SCIS were constructed on the basis of different goals, rationale and teaching methods. The ESS program provides many things for pupils to utilize with little external structure. In the SAPA program, children are to learn scientific process skills through highly structured activities. In the SCIS program, scientific concepts are introduced as appropriate for the children's intellectual development; concepts are gradually developed to higher levels of abstraction. The teacher behaviors under different curricula subsequently would be expected to be different. Hence, the thrust of this study was to assess whether or not the teacher behaviors of different curricula matched the curricular goals.

Audiotape recordings of each curriculum were randomly selected from a larger pool of recordings depicting a teacher teaching a lesson from one of the three (3) target curriculums. Two five-minute segments from each recording were randomly chosen and were recorded on separate new audiotapes in order that three trained raters could rate each five-minute segment of each tape. The raters tallied by type and frequency the teacher behaviors exhibited, using a list of 16 teacher behaviors which were selected according to their relevance to the curricular goals.

A one-way analysis of variance was used to test for differences between curricula for each category of teacher behavior. Three categories were found to be significantly different ($P < .05$ or better). In addition, the total teacher behaviors of each curriculum was significant different ($P < .001$).

ESS teachers elicited significantly more procedural planning responses from students while SCIS teachers more frequently assessed student knowledge and elicited predictions. ESS teachers utilized significantly fewer teacher behaviors overall. Although significant differences were few, those disclosed matched the goals and instructional strategies of the curricula analyzed. Most of the behaviors were exhibited by all three curricular groups. An implication here is that basic sets of skills exist that are relevant to teaching innovative science programs. Additional training would seem to be warranted if only to help teachers improve their use and integration of these skills into strategies which are relevant to student needs and curricular designs.

THE EFFECTS ON INSTRUCTION IN SCIENCE PROCESS SKILLS ON READING COMPREHENSION OF PRE-SERVICE AND IN-SERVICE ELEMENTARY TEACHERS

Richard L. Campbell

and

Emma W. Rembert
Florida International University
Miami, Florida 33125

It has been shown (Campbell and Okey, 1976; Jaus, 1975) that instruction in process skills can have an effect on teacher achievement in science. Process instruction has also been shown to change the way teachers teach reading to their pupils (Porterfield, 1969). However, no research studies have been reported that have attempted to examine what effect science process skill instruction would have on teachers' achievement in reading.

The purpose of this study was to test the hypothesis that teachers' reading comprehension can be significantly improved through the use of science process skills.

The subjects for this investigation were in two intact groups. One group consisted of juniors and seniors and the other of graduate students. Both groups were enrolled in competency based science methods courses at a southeast university during the Summer Quarter, 1976. Process skill instruction was based on two self-instructional programs; one on basic process skill (Okey and Campbell, 1973) and the other on integrated process skill (Okey and Fiel, 1971). Data were gathered on reading comprehension by administering as pre and post assessment the Nelson-Denny Reading Test, Form A (1960).

Analysis of the data, using a multivariant Repeated Measures Program (Murphy, 1976), revealed that there were significant changes ($P < .001$) on the post test scores for both the pre- and in-service teachers after studying science process skills. No differences were found between the undergraduates and graduates on the post test scores.

If it can be shown that science process skills will not only affect the way teachers teach reading, but their reading ability as well, then this information will support the contention that achievement in process skills is transferable to other academic areas.

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THE EFFECTS OF MICRO-TEACHING ON THE ATTITUDES OF PRE-SERVICE ELEMENTARY TEACHERS TOWARD THE TEACHING OF SCIENCE

Steven P. Bergel
South Country School District
Brookhaven, New York 11719

and

H. Seymour Fowler
The Pennsylvania State University
University Park, Pennsylvania 16802

The purpose of this study was to investigate the effects of micro-teaching on the attitudes of pre-service elementary school teachers toward the teaching of science. The study was based on several key, substantiated, assumptions as follows:

1. Elementary school teachers have a neutral or negative attitude toward the teaching of science.

2. A neutral or negative attitude toward the teaching of science influences an elementary school teacher's ability to adequately teach that subject.

3. Role playing is a way of changing attitudes.

4. Micro-teaching to peers is a form of role playing.

The subjects for this investigation were 120 juniors and seniors enrolled in Science Education 458 during the Fall Term 1975 and Winter Term 1976, at The Pennsylvania State University. Subjects were randomly assigned to experimental and control groups on the first day of classes in such a manner as to produce two experimental and two control sections. Two instructors were assigned the four sections so that each would teach one experimental and one control section.

At the beginning of the study all subjects in the control and experimental groups were given the Shrigley Attitude Scale for Pre-Service Teachers II. This scale measured the students' attitudes toward the teaching of science in the elementary school.

Experimental subjects then chose one lesson each, from the Science for the Seventies lessons published by the Pennsylvania Department of Education. Over a three-week period each experimental subject taught, revised, and retaught his/her lesson. The investigator developed a peer-evaluation instrument which was used by the pre-service teachers to evaluate their peers. No grades were assigned to these micro-teaching lessons.

During the same three-week period the subjects in the control group worked with, and discussed, a series of Science for the Seventies investigations. The investigations were carried out as laboratory exercises either in small groups or individually. At no time during the study did subjects in the control group do any formal teaching or receive any peer-feedback.

At the end of the three-week investigation the Shrigley Attitude Scale for Pre-Service Teachers II was administered to all subjects in both the control and the experimental group.

Due to possible differences in the samples between Fall Term and Winter Term, the data were presented and analyzed as two separate studies. These results were then compared to check on their consistency.

Two of the most important conclusions derived from this study were as follows: (1) Although the positive increase in attitudes toward the teaching of elementary school science was significant, in both studies, for the experimental group, it was not significantly greater than the increase for control group subjects. (2) An extreme positive change in attitudes (significant at the .01 level) toward the teaching of elementary school science brought about a corresponding change in teaching performance, as evaluated by peers.

Since micro-teaching to peers did increase attitudes toward the teaching of elementary school science significantly, but not significantly greater than did the control group procedures, it may have been the use of Science for the Seventies investigations, the only component common to both the experimental and control groups, which favorably increased these attitudes.

It would also appear that a dramatic, positive, change in attitudes (significant at the .01 level) toward the teaching of elementary school science may be necessary to produce a significant change in corresponding teacher performance.

CONCURRENT SESSIONS VI

Session VID - Symposium: Research Priorities

Presiding: Stanley L. Helgeson, The Ohio State University, Columbus, Ohio 43210

"Identifying Our Research Priorities"

1. "Priorities for Research in Science Education." David Butts, William Capie, Ellen Fuller, David May, James Okey and Russell Yeany, Jr., University of Georgia, Athens, Georgia 30602

2. "A Factor Analytical Study of the Research Priorities of Science Educators." Russell Yeany, Jr. and William Capie, University of Georgia, Athens, Georgia 30602.

3. "The Relationship Among Science Educators' Research Priorities and Demographic Variables." James Okey and Russell Yeany, Jr., University of Georgia, Athens, Georgia 30602.

Discussants: Gary C. Bates, Columbia University, New York, New York 10027.

Paul Koutnik, Illinois Institute of Technology, Chicago, Illinois 60616.

Edward L. Smith, Michigan State University, East Lansing, Michigan 48824.

PRIORITIES FOR RESEARCH IN SCIENCE EDUCATION

David Butts
William Capie
Ellen Fuller
David May
James Okey
Russell Yeany, Jr.
University of Georgia
Athens, Georgia 30602

A three-phase Delphi technique was used to help NARST members identify areas and priorities for research. In the first phase of the study, members were asked to nominate three areas of needed science education research. A total of 729 areas were nominated by 248 respondents and were categorized into 35 generic research statements. In the second phase, respondents assigned a priority rating to each statement. Data from these responses were analyzed to establish central tendency and dispersion characteristics for each item. The statements were then rerated by each participant after being given the group response data. Analysis of the responses from the third phase revealed a higher degree of consensus on nearly all items.

In terms of NARST member responses, the top five statements were:

1. Application of learning and cognitive development theories to classroom instruction.

2. Analysis of classroom teaching behaviors that facilitate science learning.

3. Identify what elements are essential in translating both research and development activities into classroom practice.

4. Analysis of strategies for acquisition, retention and transfer of problem solving (critical thinking or inquiry skills) in students.

5. Identification and validation of strategies to assist preservice and inservice teachers in acquiring specific teaching skills.

A FACTOR ANALYTICAL STUDY OF THE RESEARCH PRIORITIES OF SCIENCE EDUCATORS

Russell Yeany, Jr.

and

William Capie
University of Georgia
Athens, Georgia 30602

The NARST research priorities study, conducted during 1976, generated 35 science education research statements which were rated by the membership on a priorities scale. The result was a ranking of research priorities from highest to lowest.

One purpose of this factor analytical study was to condense this set (35) of statements into factors which were inherent to the set. A second purpose was to collapse the statements into fewer meaningful and manageable groups which could then represent research areas or thrusts.

The priority rankings given to each item by the respondents were analyzed through four factor analytical procedures. The first analysis set no restriction on the number of factors which could develop with eigenvalues ≥ 1 and Varimax rotation. The second analysis restricted the factors to six which was the number of identifiable factors in the first analysis. The number of factors was then restricted to five and then four in order to determine which factors were persistent.

A mean response value for the persistent factors was then constructed from the mean priority rating of the items comprising each factor.

The initial analysis indicated that there were six factors with eigenvalues > 1 underlying the 35 research statements. When the number of factors which could develop was limited to six, the nature of one factor changed somewhat because of a shift in the item loadings. When only five factors were allowed to develop, this factor disappeared and the items in it loaded on several other factors. The five factors which remained were identifiable in the initial analysis and the six-factor limited analysis. When the factor number was limited to four, the nature of the factors was much more ambiguous because of shifting items.

An examination of the mean priority rating of the five persistent factors revealed that three factors were rated equally high, the remaining two were rated well below the others.

It is possible to examine the factors which resulted from this study and identify and compare meaningful science education research areas.

THE RELATIONSHIP AMONG SCIENCE EDUCATORS' RESEARCH PRIORITIES AND DEMOGRAPHIC VARIABLES

James Okey

and

Russell Yeany, Jr.
University of Georgia
Athens, Georgia 30602

Respondents to the National Association for Research in Science Teaching Survey of research priorities also provided a variety of information about their research training, work responsibilities, research productivity, and institutions. The purpose of this study was to examine relationships among the demographic information provided by respondents and their ratings of the research statements.

Responses from the 198 NARST members who completed the third phase of the survey and who provided demographic data were used in this study. Their ratings of research statements and the demographic data were used to generate correlation coefficients so that relationships among the demographic variables could be examined as well as those between demographic variables and ratings.

A number of significant relationships were found among the demographic variables and between demographic variables and the ranking of research statements. The paper will present a complete set of the correlations determined and an interpretation of the information they provide. Information on relationships such as the following will be given in the report:

Between the amount of formal training respondents have and their research productivity.

Between the amount of budgeted research time and the research productivity of respondents.

Between the research productivity of respondents and their ranking of research statements.

Between the ranking of the importance of research by respondents and their ranking of research statements.

CONCURRENT SESSIONS VII

Session VIIA - Learning Theory: Piaget

Presiding: Marvin Druger, Syracuse University, Syracuse, New York 13210.

1. "Measurement of Logical Thinking: An Electronic Equivalent of Piaget's First Chemical Experiment." Frederick P. DeLuca, Iowa State University, Ames, Iowa 50011.

2. "The Development and Validation of a Classroom Test of Formal Operations." Anton E. Lawson, University of California at Berkeley, Berkeley, California 94720.

3. "The Construction of an Instrument to Measure Proportional Reasoning Ability of Junior High Pupils." Orville G. Ruud, Bloomington Public Schools, Bloomington, Minnesota 55431.

4. "The Validation of Two Science-Centered Incident Batteries Which Distinguish Concrete and Formal Reasoning." John W. Renner, University of Oklahoma, Norman, Oklahoma 73019.

5. "The Role of the Proportionality Schema in Introductory High School Chemistry." Heidi Kass and Alan E. Wheeler, University of Alberta, Edmonton, Alberta, Canada T6G 2G5.

MEASUREMENT OF LOGICAL THINKING: AN ELECTRONIC EQUIVALENT OF PIAGET'S FIRST CHEMICAL EXPERIMENT

Frederick P. De Luca
Iowa State University
Ames, Iowa 50011

Piagetian tasks have been criticized on the grounds that they contain misleading perceptual cues, discriminate against female subjects, fail to yield high intercorrelations at the same developmental level, and require bulky material and a relatively long time to administer. The purpose of this investigation was to make a preliminary assessment of the possibility of transforming Piaget's first chemical task into an electronic equivalent which would retain the advantages of the chemical task while sharply reducing the grounds for criticism mentioned above.

An electronic equivalent of Piaget's first chemical experiment was designed and constructed. The chemical task and its electronic equivalent were included in a battery of five tasks, and were randomly switched between the first and fifth positions in the order of administration. The other three tasks served as a buffer and always occupied the same positions--second, third and fourth.

The battery of Piagetian tasks were administered on an individual basis to 64 intermediate-ability twelfth graders enrolled in chemistry. The age of the subjects ranged from 17 years-2 months to 17 years-4 months with a mean age of 17 years-7 months. The high school enrolled over 1300 students and was estimated to rank in the upper 25 percent nationally for schools of its size.

Contingency matrices for the comparison of tasks and sex, order of tasks, and between tasks were constructed. Chi-square analyses of the data indicated no significant relationship between task scores and sex, nor between task scores and order of administration. A significant relationship between the chemical task and its electronic equivalent was found ($X^2 = 33.26$, $df = 1$, $p < .001$). The phi coefficient of correlation between the two tasks was .72.

Time for administration of the chemical task ranged from 11 to 22 minutes with a mean time of 14 minutes per subject. Time for administration of the electronic task ranged from 3.2 minutes to 6.5 minutes with a mean time of 4.4 minutes per subject.

Both the chemical and electronic tasks were sex-free and equally effective in discriminating between concrete and formal operational subjects. The electronic task provided several advantages: 1) better control of the variables, 2) more compact and easily transported, and 3) could be administered in one-third of the time required to administer the chemical task.

This study provides the researcher with an electronic task which can retain the effectiveness of the chemical task and reduce its disadvantages. The electronic task can serve as a prototype for the transformation of other Piagetian tasks. Interfacing subjects with an electronic task also makes possible the use of modern electronics to collect, store, and process data in new and more efficient ways.

THE DEVELOPMENT AND VALIDATION

OF A CLASSROOM TEST OF FORMAL OPERATIONS

Anton E. Lawson
University of California at Berkeley
Berkeley, California 94720

Individually administered Piagetian tasks, although found to be valid indicators of formal reasoning, require an experienced interviewer, special equipment and are too time consuming for practical classroom use.

The problem of this study was to develop and validate a test which would: (1) reliably measure concrete and formal operational reasoning; (2) be capable of administration to classes of secondary school and college students in a relatively short period of time; (3) be easily scored; and (4) use a format involving physical materials requiring as little reading and writing as possible.

Fifteen items were constructed for the test. Each item involved a demonstration used to pose a question. Students responded in writing on booklets which contained only the questions followed by a number of possible answers and spaces for answer justification.

The test was administered to 513 8th, 9th and 10th grade students from schools located in two suburban communities in the San Francisco Bay area.

Scores on the classroom test ranged from 0-15, $\bar{X} = 7.41$, SD = 4.27, standard error of measurement = 2.1; 35.3 percent of the Ss were categorized as concrete, 49.5 percent were classified as transitional, while 15.2 percent were classified as formal operational. The KR-20 estimate of reliability was .78.

To assess validity of the test as a measure of formal operations, five types of evidence were sought:

1. The relationships between level of response on the test and level of response on two Piagetian interview tasks were determined. Significant positive correlations ($p < .001$) were found between the test and the bending rods and balance beam tasks ($r = .76$, $r = .65$ respectively). This suggests that the test and the tasks are measuring the same parameters.

2. Since the 8th and 10th grade Ss were drawn from the same population, the 10th grade Ss should perform at a more formal level. The 10th grade Ss did achieve a significantly higher mean score ($t = 5.62$, $df = 319$, $p < .001$).

3. A comparison of performance of 9th grade Ss enrolled in either a standard English course or a remedial English course on the classroom test was made. One would expect to find a significant relationship between need for remediation in English and lack of formal reasoning. Seventy-six percent of the remedial English Ss performed at the concrete level, 22 percent performed at the transitional level, while only 2 percent performed at the formal level. In the standard English classes the respective percentages were 22 percent, 53 percent and 25 percent. The mean scores of the two groups differed significantly ($t = 7.05$, $df = 190$, $p < .001$).

4. Correlation coefficients between the classroom test scores and achievement test scores in reading, language arts, mathematics, social studies, and science were computed. High positive correlations were obtained with achievement in all areas (.60 to .73). This indicates that the test measures psychological parameters fundamental to all of these areas of intellectual functioning.

5. A principal components analysis of the test items and the interview tasks was performed. Three principal components were isolated and identified as concrete, transitional, and formal reasoning. These results indicate that the classroom test is factorially valid.

The major conclusion of this study is that the same psychological parameters measured by Piagetian interview tasks were measured by a series of classroom demonstration items with a fairly high degree of reliability. The items were easily administered to entire classes of students in a short period of time and quickly scored. The classroom test was found to be valid.

The classroom test is intended primarily for use by teachers interested in knowing the developmental levels of their students. Use of the test as a source of knowledge about student reasoning can be extremely worthwhile, but only if teachers understand the nature of concrete and formal thought and understand how to adapt course content, goals, methods, and evaluation procedures to fit these levels.

The identification of "concrete operational" students, coupled with appropriate modifications in teaching practice, hopefully could do a great deal for them in eliminating the rote-meaningless memorization of cognitively unassimilatible material, and the frustration and intellectual stagnation that results from such a psychologically unpalatable diet. Also, as a number of recent studies suggest, such modifications could significantly aid these students in their development of formal reasoning. Use of the classroom test could also benefit "formal operational" students who have been mistakenly placed into classes for remedial-learning by their identification and subsequent transfer into regular classes.

THE CONSTRUCTION OF AN INSTRUMENT TO MEASURE PROPORTIONAL REASONING ABILITY OF JUNIOR HIGH PUPILS

Orville G. Ruud
Bloomington Public Schools
Bloomington, Minnesota 55431

This study accomplished the development of a paper-pencil test for large scale measure of proportional reasoning ability in the context of physical science. The test assists in establishing pupil levels as related to course requirements for this type of reasoning. In the development of the examination, the Piagetian literature on formal intellectual growth was used to establish the form and the validity of paper-pencil tests.

Test development was accomplished through task and paper-pencil testing of students in elementary, junior high and senior high schools of one Minneapolis suburb. Individual task-testing of a representative group of 40 pupils was used to establish a reference group for paper-pencil testing and to determine probable topics for test items. Tests were administered to 2027 pupils in arriving at the final test and the description of its characteristics. Initial explorations of the problem were stated in the Fall, 1973. The final testing was completed in the Spring, 1976. The testing involved groups of pupils who, by reason of age, were assumed to be non-masters, at the transitonal stage, or masters of formal proportional reasoning. Responses to the items were examined after each testing. Items were omitted, revised or retained based upon their demonstrated difficulty level, discrimination between masters and non-masters and consistency with other items belonging to the same level.

Five major revisions were made of the item sets comprising the test. The initial version had 77 items. The final test form consisted of 24 items with four sub-sets each for a Piaget level: Concrete Operational I (Level 1), Concrete Operational II (Level 2), Formal Operational I (Level 3), Formal Operational II (Level 4). This final test version was completed by 90 percent of the eighth grade pupils in a 30-minute testing period and required no special directions from the test administrator.

Results showed that the final version was valid. Content validity met the criterion that items in each level should ask for behavior meeting the specifications of Piaget for that level of proportional reasoning. Concurrent validity was demonstrated in the Pearson correlation coefficient of .36 between average task ratings and the paper-pencil ratings of pupils. Construct validity was evident in the higher correlation, .53, of the test with non-verbal than with verbal Lorge-Thorndike IQ, .35; the scaled difficulty level of groups of items and the agreement of the number of pupils determined at the levels with the numbers found by Hensley, Karplus and Lawson.

The test had good reliability. Overall test reliability, Kuder-Richardson 20, was .77. Reliability calculated according to Livingston's approach for criterion-referenced tests was .84. Reliability calculated from test-retest results for 338 pupils had a Pearson value of .83 for overall score reliability and .84 for the discrimination of formal and concrete levels.

Test items exhibited good discrimination in that r biserial values of .50 or better were obtained for 18 of the 24 test items. Eighth grade suburban junior high pupils were described by the test to be 23 percent Preoperational, 21 percent Concrete I, 20 percent Concrete II, 23 percent Formal Operational I and 13 percent Formal Operational II.

Paper-pencil tests of Piaget measures in other areas of cognitive development could be designed following the strategy of this study. The group test of this study and others like it should be used by teachers in evaluating the level of proportional reasoning in their classes. Continued large scale testing could be utilized to develop alternative forms of the test.

THE VALIDATION OF TWO SCIENCE-CENTERED INCIDENT BATTERIES WHICH DISTINGUISH CONCRETE AND FORMAL REASONING

OBJECTIVES AND THEORETICAL RATIONALE

John W. Renner
University of Oklahoma
Norman, Oklahoma 73019

Individually administered Piagetian tasks, although found to be valid indicators of formal reasoning, require an experienced interviewer and special equipment and are too time consuming for practical classroom use.

The purpose of this study was to develop science-centered incidents, each of which required proportional reasoning, combinatorial logic or the ability to separate and control variables to be solved. The incidents enabled students to respond in writing, and, therefore, enabled large groups to be tested at one time. Success on the incidents was then correlated with success of the students on Piagetian tasks administered by interview.

Twelve incidents were prepared. The subject matter was kept at the junior high school level and the reading levels were no higher than grade six. Student responses were read by specialists in the Piagetian model and a rating scale was prepared for each incident. Ratings from the incidents were then correlated with ratings received on the Piagetian interviews.

The Piagetian interviews were administered to 811 tenth, eleventh, and twelfth grade students from fifteen Oklahoma high schools. No less than 200 of those interviewed completed each group of three incidents. After the most successful incidents were identified, two groups of three incidents were administered to 240 students.

Seven of the 12 incidents produced written responses that could be used to separate the reasoning patterns of the students into separate categories. Two of those incidents measured proportional reasoning, two measured combinatorial analysis, and three measured the ability to separate and control variables.

The results of the Piagetian interviews demonstrated that 67.4 percent of the reasoning found was concrete and 42.6 percent could be classed as formal. Only 10.8 percent of the reasoning found, however, could be classed as IIIB.

The highest correlation between success on the incidents and success on the Piagetian tasks was found when student scores were each treated as additive scores and then correlated. Pearson correlation coefficients between the variables were approximately 0.5 when success on each individual incident was correlated with

a Piagetian score. Those correlations rose to around 0.7 when success on an incident of each thought type was summed and correlated with success on the Piagetian tasks. The multiple-R technique was used in the latter case.

Two batteries of three incidents each exist. Each battery contains one incident which measures proportional reasoning, one that measures combinatorial logic, and one that measures the ability to separate and control variables. With the statistical techniques used, the best predictor among the incidents in each battery is known. These incidents will be useful to (1) measure the intellectual levels of groups, and (2) to utilize in classrooms and research when pre- and post-tests are needed to study intellectual development shifts.

THE ROLE OF THE PROPORTIONALITY SCHEMA IN INTRODUCTORY HIGH SCHOOL CHEMISTRY

Heidi Kass

and

Alan E. Wheeler
The University of Alberta
Edmonton, Alberta, Canada T6G 2G5

Recent curriculum reform in science programs at the secondary level has, in general, led to an increased emphasis on the structure of the subject matter. Somewhat lesser concern has been expressed for the organization of science curricula on the basis of knowledge about the students' cognitive development. If curriculum planning is to respect the sequence of development of students in general, and of individual students in particular, more information is required about the nature of cognitive development as it relates to specific aspects of the science curriculum. Rather than merely using science content as a convenient subject-matter vehicle to test various psychological notions, the emphasis of research in science instruction should be directed towards more basic science-specific studies, with clearer implications for classroom practice. The schemata described by Piaget provides a means to identify types of understandings and thought processes available to students. The study described here focused on the proportionality schema and its relationship to certain areas of introductory high school chemistry.

The main purpose of the study was to ascertain the extent to which students' perceptions of the proportionality schema are related to achievement in introductory chemistry. The central question of the study was: Is the ability to apply proportional reasoning a significant factor in achievement in selected areas in introductory high school chemistry?

A total of 309 grade 10 students, comprised of an ALCHEM Materials sample (N = 168) and a CHEM Study sample (N = 141), enrolled in four urban senior high schools was tested under normal classroom conditions.

A set of four collectively administered neo-Piagetian Reasoning Tasks (RT) served as a measure of students' cognitive functioning level. Two equivalent forms of a General Proportionality Test, GPT(A) and GPT(B), served to indicate students' performance on general proportional reasoning. Four subtests of a Chemistry Proportionality Test (CPT) dealt with the topics: Nomenclature and the Writing of Formulae, CPT(1); Chemical Reactions, CPT(2); the Mole Concept, CPT(3); and Gravimetric Stoichoimetry, CPT(4). A Chemistry Achievement Test (CAT), covering all sections of the Chemistry 10 program, provided a general measure of achievement in chemistry.

In terms of cognitive functioning, the total sample (N = 309) was classified as: concrete operational, 89 students (28.8 percent); transitional, 69 students (22.3 percent); early formal, 84 students (27.2 percent); and late formal, 67 students (21.7 percent). The existence of a prevalent "additive" mode of reasoning associated with concrete operational thinkers was noted with respect to selected proportionality tasks.

Significant correlations were found to exist between proportional reasoning in chemistry (CPT) and (1) achievement in chemistry (CAT), (2) cognitive level (RT) and (3) proportional reasoning in a non-chemistry context (GPT). Instruction in proportional reasoning in chemistry did not appear to enhance general proportional reasoning. Regression analysis to predict chemistry achievement (CAT) found only the chemistry proportionality subtests significant predictor variables. A principal factor solution identified three main factors, the first associated with the CPT subtests and achievement (CAT) and the second with the reasoning Tasks (RT). The third factor contained high loadings for the verbal reasoning and analogy items on the two forms of the GPT. A significant chi square, in favor of the boys, was noted between sex and cognitive level.

Related findings failed to detect a hierarchical structure associated with general proportional reasoning. However, results relating to proportional reasoning in a chemistry context supported a hypothesized sequence of capabilities (conversion - ratio - direct proportionality). Three areas of problem solving in introductory chemistry (mole relationships, interpretations of chemical equations and the use and effectiveness of dimensional-analysis) together with implications for classroom science teaching are discussed in relation to preliminary findings.

CONCURRENT SESSIONS VII

Session VIIB - Instruction

Presiding: John W. Butzow, University of Maine, Orono, Maine 04473.

1. "An Experiment in Science Instruction with Fifth Grade Children in Spanish-English Bilingual Schools." John R. Juarez, University of Washington, Seattle, Washington 98195.

2. "The Influence of Spatial Abilities, Aptitudes, and Attitudes on Success in Geology." Osborne B. Nye, Jr., Larry E. Schafer, and James C. Brower, Syracuse University, Syracuse, New York 13210.

3. "An Exploratory Study of Teacher Interventions in Elementary Science Laboratory Groups." Wayne F. Oakley, Department of Education, Province of Newfoundland, St. John's, Newfoundland and Robert K. Crocker, Memorial University of Newfoundland, St. John's, Newfoundland.

4. "The Effects of Diagnostic Testing and Remediation on Science Achievement and Retention." Joe C. Long, James R. Okey and Russell H. Yeany, Jr., University of Georgia, Athens, Georgia 30602.

5. "Application of Bales Interpersonal Model to Science Teaching." Gary C. Bates, Columbia University, New York, New York 10027.

AN EXPERIMENT IN SCIENCE INSTRUCTION WITH FIFTH GRADE CHILDREN IN SPANISH-ENGLISH BILINGUAL SCHOOLS

John R. Juarez
University of Washington
Seattle, Washington 98195

This paper discusses research on the effects of science instruction in subordinate and superordinate science process skills on the relevant performance of bilingual fifth grade children. The purpose of this study was to determine if single language instruction is any more efficacious than bilingual instruction in a science context. A main concern was the transfer of learning science content and process skills from one language to another. Additionally, information is presented on the students' reactions to bilingual science instruction.

The population of children came from four schools that had bilingual education four years prior to the investigation. There were four treatment groups, and the student assignment was determined by randomization. The experimental design employed was a 2 x 2 factorial design with equal replication in each of the four schools. All science instruction was carried out by four bilingual teachers, and testing was done individually. There were two independent variables, science and language, and three dependent measures. The three dependent measures consisted of two competency measures to determine acquisition of stated objectives, and the third dependent measure was a language preference and attitude inventory.

Data were obtained from fifth grade children from four different schools in New Mexico. Prior to the instruction of children, all teachers were trained in the use and presentation of selected science units based on AAAS (SAPA). In addition, information was obtained on student language preference and attitude toward science instruction.

The results of the investigation indicated that there is no significant difference between treatment groups receiving instruction bilingually and those having single language instruction. The students receiving total instruction in English did no better on the dependent measures than did those students receiving total instruction in Spanish, and students receiving instruction in both Spanish and English performed just as well as those instructed in a single language. The students showed a statistical preference for a bilingual environment as opposed to a monolingual environment. This was significant at the .05 level.

This research is of significance because it employs a cumulative learning model for assessing the transfer of learning in a bilingual classroom. The design was experimental, had control groups, and therefore can be replicated. Instruments to assess performance of the treatment groups were conventional instruments

in a national science curriculum project, and give evidence of measuring cognitive development. Secondly, a new dependent measure was developed to investigate the language preference and attitude of bilingual children following bilingual science instruction. Additionally, the experimental evidence indicated that children were able to transfer previously learned science process skills in one language to higher level science process skills in another language. Thus, one of the fundamental assumptions in bilingual education was further supported. The study provides information for further investigation regarding the teaching of science to bilingual children, and makes important suggestions regarding this research.

THE INFLUENCE OF SPATIAL ABILITIES, APTITUDES, AND ATTITUDES ON SUCCESS IN GEOLOGY

Osborne B. Nye, Jr.
Larry E. Schafer
James C. Brower
Syracuse University
Syracuse, New York 13210

Numerous studies of spatial abilities have demonstrated correlation with performance in the physical sciences. One would suspect that correlation with success in earth science would be high because data are largely collected from two dimensional exposures of three dimensional objects. Examples are the construction of maps and cross-sections to find resources such as water and energy, and the visualization of atomic structure in minerals. Despite the probable importance of this cognitive skill, it has received little attention by earth science educators. We have begun to investigate this skill by testing students at all levels, and even some of the faculty. Our interest here is twofold: (1) to assess the importance of spatial abilities, and (2) to measure the effect of spatial abilities relative to other factors which correlate with performance in the introductory geology course.

The variables observed on 100 college students taking introductory geology at Syracuse University were: attitude towards geology (ATG), self-concept in geology (SCG), SAT Math, SAT Verbal, DAT for spatial relations, sex, laboratory spatial grade, laboratory total grade, final exam grade, and course total grade. SCG and ATG were measured by semantic differential instruments. An initial premise was that lab scores, especially those for mapping and other spatially related exercises, would correlate more highly with spatial abilities than would lecture scores. All four performance scores were highly correlated; consequently only course total is reported here. The statistical techniques applied to this data were stepwise multiple regression and factor analysis.

Using course total as the dependent variable, about 55 percent of the variation was accounted for by attitude and aptitude variables. Of these, SAT Math and spatial ability were clearly isolated as the best predictors of success because these two accounted for 53 percent of the variance in course total. Of the variables measuring attitudes, self-concept was more associated with success than was attitude towards geology. The remainder of the variance must be accounted for by unmeasured factors such as perseverance, study habits, health, etc.

The factor analysis surveyed the overall relations between the variables and students. For example, the first factor represented an overall performance, attitude, and aptitude package which accounted for 46 percent of the variance in the correlation matrix.

Of the aptitude variables, spatial relations contributed most to this factor. The only variable that loaded highly on Factor III was sex (19 percent of the variance), which showed that attitude, aptitude, and performance were divorced from sex.

Spatial abilities are important in the earth sciences at the introductory level. Preliminary investigation of data gathered from higher-level students and faculty reinforce this conclusion. Clearly, improvements in curriculum design and teaching methods should be based on this premise. Moreover, there is a definite need for special exercises designed to aid students with marked deficiencies in spatial ability.

AN EXPLORATORY STUDY OF TEACHER INTERVENTIONS IN ELEMENTARY SCIENCE LABORATORY GROUPS

Wayne F. Oakley
Department of Education
Province of Newfoundland
St. John's, Newfoundland

and

Robert K. Crocker
Memorial University of Newfoundland
St. John's, Newfoundland

This study formed one aspect of a broader study designed to explore teacher-pupil and pupil-pupil relationships in the context of elementary science activities, the characteristic surface feature of which was the predominance of small group work by pupils, without continuous teacher direction. Such activities are typical of those found in most of the major elementary science curricula. The specific rationale for the study of teacher interventions stems from a consideration of the possible contrast between pupil behavior relative to the teacher in small groups as compared to larger (class size) groups. Pupil roles in conventional classes have been widely investigated and the general pattern of pupil behavior relative to the teacher in such classes is reasonably well established. In a situation of teacher interaction with small groups (in this study, groups of two) it is possible that pupil roles vis a vis the teacher may differ from that in the large group. It is also of interest to examine the possible change in a pupil's role when the interaction is with other pupils rather than with the teacher.

Two pairs of pupils from each of ten classes were recorded for a single class session using two independently operated portable videotape recorders. The lessons being taught were from an elementary science curriculum that, for purposes of this study, may be regarded as structurally similar to the program Science - A Process Approach. Typed transcripts were prepared from the videotapes and the transcripts coded using a modified version of the Bellack classroom analysis system. The modifications were designed to reflect the process nature of the activities, to more strongly emphasize the notion of teacher control in the instructional dimension, to permit coding of physical actions, and to permit identification of individual pupils as both senders and receivers of communication.

An analysis of intervention numbers and lengths revealed wide variations, with frequency of interventions decreasing sharply as intervention length increased, but with number of interventions per group being more evenly distributed. Teachers appeared to employ a relatively random pattern with respect to amount of time

spent with groups, indicating that intervention time is controlled by the teacher rather than the pupils. Differences did, however, occur between teachers in intervention times.

Teacher and pupils were found to initiate about equal numbers of interventions, with intervention time showing no variation with initiator. Reasons for initiating an intervention did differ, with the teacher initiating mainly to give procedures or to solicit progress reports and pupils initiating primarily to report observations or to give progress reports. Behavior patterns during interventions differed with intervention length. Longer interventions, regardless of initiator, almost invariably ended with the teacher giving directions on procedures.

As in conventional classes, the proportion of teacher talk was almost universally greater than for the two pupils combined. The conventional pattern whereby the teacher solicits and pupils respond was also upheld. A number of significant differences between the nature of teacher and pupil discourse emerged when specific categories in the analysis system were tabulated by speaker.

With respect to pupil characteristics, only the extraversion variable showed a significant correlation with behavior variables. Comparison of pupil behavior during the interventions with those in the absence of the teacher revealed differences in the categories of pupil responses and requests.

Within the limitations imposed by the exploratory nature of the study, the results have potential implications for role theory in that it appears that teacher and pupil roles show a high degree of stability even under seemingly large changes in the surface structure of the classroom setting. Ordinarily, classrooms in which small groups of pupils are working with apparatus and in which the teacher's time is largely spent in interacting with these groups rather than with the class as a whole would be considered to be fundamentally different from more conventional lecture or recitation type classes. In fact, many research studies have compared these types of classes in terms of contrasting teaching strategies (using terms such as expositories - hypothetical, inductive - deductive, teacher centered - pupil centered, etc.). The more detailed analysis of teacher-pupil relationships provided here suggests that these contrasts may be more apparent than real.

THE EFFECTS OF DIAGNOSTIC TESTING AND REMEDIATION ON SCIENCE ACHIEVEMENT AND RETENTION

Joe C. Long
James R. Okey
Russell H. Yeany, Jr.
University of Georgia
Athens, Georgia 30602

A number of studies over the last few years have shown that diagnostic tests followed by remedial instruction can be used to increase the achievement of students (e.g., see the review by Block and Burns, 1976). Similar learning effectiveness studies as well as studies of the conditions under which initial achievement and retention are maximized are still under way. The purpose of this study was to provide students with differing types of learning guidance following diagnostic testing and to examine the effects on science achievement and retention.

A total of 154 seventh-grade students from six classes participated in the study. All students completed a five-week block of instruction in earth science composed of units on earth motion, latitude and longitude, and map skills. Teachers within the school taught the classes and were provided with performance objectives, diagnostic progress tests, unit tests, learning materials, and activities keyed to the objectives.

Students were stratified on three levels of aptitude and randomly assigned to one of the following treatment conditions:

Treatment 1: (Teacher-Directed Remedial Work) Students were provided objectives and related learning materials. Diagnostic progress tests were given at about 2-day intervals over the objectives just studied. The tests were scored and students were guided by the teacher to complete specific additional instruction. A second progress test was then given.

Treatment 2: (Student-Directed Remedial Work) Students followed instruction the same as in Treatment 1 except that no specific assignments were made following administration of the diagnostic progress test. Instead, students were told to use the results to guide their own efforts to correct errors. No follow-up progress tests were given.

Treatment 3: (Control Group) Students received the same basic instruction as the other two groups except that no diagnostic progress tests were given and no remedial instruction undertaken.

Science achievement was measured with tests (referenced to the objectives) at the end of each of the three units. Retention was measured with an objectives-referenced test approximately seven weeks after study of the materials was completed.

Achievement and retention data were analyzed using a 3 x 3 (aptitude x treatment) analysis of covariance design. Verbal and quantitative scores from the Iowa Test of Basic Skills were used as covariates. Significant treatment effects on the initial achievement scores were found ($p < .001$). Both groups of students receiving diagnostic tests scored significantly higher than control group students. Significant differences were found between the two groups of students that received teacher- or self-guided remediation on only one unit. Analysis of the retention test data showed that initial differences measured were not apparent after a two-month span.

The continuing development of procedures to maximize both achievement and retention in science education is important. Findings from this study have both supported and contradicated results from other studies on diagnostic testing and remediation. Effects of diagnosis and remediation were not consistent across all units. Other studies have found differential effects due to type of remediation and retention of initial achievement. Additional studies are needed to determine the contexts in which diagnostic testing and remediation are most effective.

Block, J. and R. Burns. "Mastery Learning." In L. Shulman (Ed.) Review of Research in Education, Vol. 4. Itasca, Illinois: Peacock Publishers, 1976.

APPLICATION OF BALES INTERPERSONAL MODEL TO SCIENCE TEACHING

Gary C. Bales
Columbia University
New York, New York 10027

The interpersonal interaction between teacher and student has long been recognized as an important component of teaching. The need for practical, objective measures of the interpersonal domain is becoming increasingly important for science education as science teachers begin to discuss values questions relating to the interaction of science and society and as competency based teacher education programs are introduced which require objective assessment procedures. Bales interpersonal role model has previously been used in science education research to study the decision making of small student groups and in the analysis of personality variables used to predict classroom climate variables.

The primary objective of the current study was to use factor analytic techniques to test the hypothesized three dimensional orthogonal structure of the Bales model when applied to science teachers, using a paper and pencil instrument derived largely from the items which Bales has used in his studies of small groups at the college level. A second objective was the development of computer programs capable of quickly processing classroom data and providing summarized data in tabulated and graphic form to facilitate interpretation of results to teachers and interns.

Data for the initial phase of the study were gathered during the spring of 1976 from 566 students in 31 classes of 12 student teachers working in suburban high schools. (A few urban and junior high school classes were also sampled but were generally unable to satisfactorily complete the instrument.) Items from each of the 26 regions of the interpersonal factor space were combined into 13 bipolar scales of 4 items each. Alpha reliabilities for five scales were in the .6 to .7 range, six scales had reliabilities of .3 to .4, and two scales .1 to .2. In general the most reliable scales described "acceptable" teacher roles while scales associated with nontraditional teacher behavior had low reliabilities. A principal components factor analysis demonstrated that three factors consistent with the hypothesized dimensions of the model accounted for 65 percent of the variance and the communalities suggest that these three factors include essentially all of the true variance from each scale. Considerable confounding exists among some of the variables, which is not particularly surprising considering the expected role behavior of teachers and the probable self-selection bias for persons who choose teaching.

At the present time a revised form of the instrument is being designed to more sharply distinguish among the three hypothesized dimensions and which can be administered to classroom groups, used in small group interviews, or be utilized by observers. It is anticipated that preliminary data from the second study may be available for the March meeting.

CONCURRENT SESSIONS VII

Session VIIC - Paper Set: Competency Based Teacher Education

Presiding: Alan M. Voelker, Northern Illinois University, DeKalb, Illinois 60115.

1. "Cognitive Gains Assessed by a Self-Made Instrument for a Competency-Based Teacher Education Program." Otis Lawrence, Governors State University, Park Forest South, Illinois 60466.

2. "Correlating Beliefs About Science and Science Teaching with Preferred Learning Styles." Leon J. Zalewski, Governors State University, Park Forest South, Illinois 60466.

3. "Comparison Between Elementary Science Education and Non-Science Education Majors." Donna Siemro, Governors State University, Park Forest South, Illinois 60466.

4. "The Difference Competency-Based Science Teachers Make: Student Variables." Eugene Nuccio, Governors State University, Park Forest South, Illinois 60466.

5. "Changes in Teacher Attitudes and Behaviors with Time in the Classroom." John Hockett, Governors State University, Park Forest South, Illinois 60466.

COGNITIVE GAINS ASSESSED BY A SELF-MADE INSTRUMENT FOR A COMPETENCY-BASED TEACHER EDUCATION PROGRAM

Otis Lawrence
Governors State University
Park Forest South, Illinois 60466

In 1975 the faculty of the Science Teaching Program initiated an overall evaluation process by implementing a criterion-referenced (C-R) system for measuring student achievement of competency. The faculty developed a C-R measurement system according to a model developed by Jesse H. Webb of the Educational Testing Service Corporation (1973). Test items have been written, analyzed and reviewed by the total faculty. Faculty consensus determined suitable test items for the C-R itstrument. An item bank has been established and preliminary testing results have been analyzed.

Preliminary data indicate that achievement has been reached in several competency areas. This paper will describe procedures used in determining achievement and results from preliminary testing.

CORRELATING BELIEFS ABOUT SCIENCE AND SCIENCE TEACHING WITH PREFERRED LEARNING STYLES

Leon J. Zalewski
Governors State University
Park Forest South, Illinois 60466

One factor, preferred learning styles of students, plays an integral part in the amount of learning that will ultimately take place. The data indicate that students enrolled in the competency-based Science Teaching Program at Governors State University prefer a collaborative and participant learning style. Learning style preferences were determined by using a Student Learning Style instrument assessing six student learning styles.

Students enrolled in the graduate and undergraduate Science Teaching Program demonstrate an appropriate belief system toward science teaching and science. This research will focus upon correlations between student learning styles and changes in beliefs toward science and science teaching. Specifically, the question investigated will be: Which subscale learning style preference prevents changes in beliefs toward science and science teaching?

COMPARISON BETWEEN ELEMENTARY SCIENCE EDUCATION AND NON-SCIENCE EDUCATION MAJORS

Donna Siemro
Governors State University
Park Forest South, Illinois 60466

The course, Teaching Elementary School Science, is a component of the K-12 science teacher certification program in the College of Environmental and Applied Science at Governors State University. This course is also a requirement for elementary education majors in the College of Human Learning and Development at the university. Normally Teaching Elementary School Science is the only course in the College of Environmental and Applied Science taken by students from the College of Human Learning and Development. Do students enrolled in a science teacher education curriculum differ significantly in specific personality traits and beliefs about science teaching from students enrolled in a general elementary education curriculum? The objective of this exploratory research is to identify personality traits, beliefs about learning, and beliefs about science teaching that may characterize students enrolled in the K-12 science teaching program at Governors State University.

Instruments used in the study include:

1. Rokeach Dogmatism Scale.
2. Gough-Sanford Rigidity Scale.
3. Assumptions About Learning and Knowledge.
4. Beliefs About Science and Science Teaching.

THE DIFFERENCE COMPETENCY-BASED SCIENCE TEACHERS MAKE: STUDENT VARIABLES

Eugene Nuccio
Governors State University
Park Forest South, Illinois 60466

Graduates of the competency-based Science Teaching Program at Governors State University demonstrate skills in promoting inquiry in science education and a changed belief system toward the role of science in everyday life. The impact these behaviors and beliefs have on their students is an important evaluation of competency-based curriculum's efficacy. This research seeks to determine the influence on student cognitive and affective outcomes directly attributable to competency-based training.

Matched-samples of graduates from the M.A. Science Teaching Program at Governors State University and sister institutions are compared across several student outcome variables. Standardized science achievement tests, the appropriate form of Walberg's Learning Environment Inventory, and an inventory of science-related beliefs are analyzed for each classroom. Statistical comparisons evincing the convergencies and divergencies of competency-based -vs- non-competency-based teacher preparation are highlighted within the data restriction. Program modifications and evaluations are indicated.

CHANGES IN TEACHER ATTITUDES AND BEHAVIORS WITH TIME IN THE CLASSROOM

John Hockett
Governors State University
Part Forest South, Illinois 60466

Students at Governors State University develop competencies in selecting and using teaching behaviors based on their goals for specific student groups and on a publicly stated set of values. When graduated from the program, those and other competencies are measured in three ways: (a) by course performance, (b) by a terminal project, and (c) by an independent testing system. This study is directed at measuring and describing changes in expressed teacher goals and values and in the teaching behaviors, as measured by student perceptions, as a function of the time which has passed since graduation at the M.A. level.

Instruments involved include a Q sort of science teaching activities, Schwirian's Science Support Scale, and a Likert-type opinionnaire for students. Teachers in the study are employed from the primary grades to community college.

Session VIID - Paper Set: Teacher Education

Presiding: Barbara Strawitz, Louisiana State University, Baton Rouge, Louisiana 70808 and James F. Barufaldi, University of Texas, Austin, Texas 78712.

1. "Attitudinal Changes and Open-Mindedness of Preservice Elementary Teachers Following a Science Methods Course." Martha K. Piper and Linda Hough, University of Houston, Houston, Texas 77004.

2. "The Effects of an Elementary Science Methods Course on the Attitudes of Preservice Teachers Toward Science." Lowell J. Bethel, The University of Texas, Austin, Texas 78712, Martha Piper, University of Houston, Houston, Texas 77004 and William G. Lamb, Delta State University, Cleveland, Mississippi 38733.

3. "The Effects of Methods Course Components on Elementary Education Majors: Replication and Extension." William G. Lamb, Delta State University, Cleveland, Mississippi 38733, Martha Piper, University of Houston, Houston, Texas 77004 and Lowell J. Bethel, The University of Texas, Austin, Texas 78712.

ATTITUDINAL CHANGES AND OPEN-MINDEDNESS OF PRESERVICE ELEMENTARY TEACHERS FOLLOWING A SCIENCE METHODS COURSE

Martha K. Piper

and

Linda Hough
University of Houston
Houston, Texas /7004

A significant deterrent to effective teaching of science in the elementary school today is the negative attitude of teachers toward science and the teaching of science. In spite of nationwise efforts to train teachers to teach the elementary science curricula developed over the past decade, little progress has been made toward improving the attitudes of elementary teachers toward teaching science (Thomson and Thompson, 1976). Part of the problem may stem from the way in which students learn science in college. Butzow reported,

> It appears that the concept of science as a body of verified knowledge was so overstressed that each time an explanation or method of finding a solution to a problem was not mastered, the teacher-to-be was moved further away from liking science. The irony of this is that teachers themselves imitate the method by which they become so frustrated (Butzow, 1973, p. 20).

A recent study (Piper, 1976) indicated that preservice elementary teachers changed their attitudes toward science in a positive direction following a methods course that stressed problem solving activities through guided discovery. Elementary majors enrolled in the course were encouraged to explore new ideas about science and teaching science. In addition, they were given an opportunity to practice their new teaching ideas with children in the public schools. A science methods course that emphasizes the "finding out" aspect of learning science may affect a person's belief system as well as his attitudes. According to Rokeach (1960), beliefs are not singular but exist in systems and one of the characteristics of a person's belief system is the degree of open-mindedness that exists in his belief system.

> ...a basic characteristic that defines the extent to which a person's system is open or closed; namely, the extent to which the person can receive, evaluate, and act on relevant information unencumbered by irrelevant factors in the situation arising from within the person or from the outside (Rokeach, 1960, p. 57).

In 1975, Bogut investigated the relationships between pre-service teacher's attitudes and degree of open-mindedness. Bogut concluded that degree of initial open-mindedness appeared to be the most important factor in producing attitudinal changes. This study continues to explore the relationship between attitudinal changes and degree of open-mindedness.

The purpose of this study was to investigate relationships between attitude changes and changes in degree of open-mindedness following a science methods course. The following questions were investigated:

1. Is there a change in degree of open-mindedness of elementary majors following a competency-based, field-oriented science methods course?

2. Is there a correlation between positive attitude changes and degree of open-mindedness of elementary majors following a competency-based, field-oriented science methods course?

3. Is there a change in attitudes and degree of open-mindedness of students who have positive attitudes toward science and are open-minded following the science methods course?

4. Is there a change in attitude and degree of open-mindedness of students who have positive attitudes toward science and are closed-minded following the science methods course?

5. Is there a change in attitudes and degree of open-mindedness of students who have a negative attitude toward science and are open-minded following the science methods course?

5. Is there a change in attitude and degree of open-mindedness of students who have a negative attitude toward science and are closed-minded following the science methods course?

The subjects were 92 elementary majors enrolled in a science methods course. The subjects in the control group were 90 students enrolled in a physics course. All subjects were given pretests and posttests using two instruments: (1) the Rokeach Dogmatism Scale, Form E and (2) the Jaus Attitude Toward Teaching Science. The instruments were given in August, 1976, at the beginning of physics and science methods courses and again in December at the end of the courses.

A one way analysis of variance was used to analyze changes in degree of open-mindedness (question #1) and to determine if there is a correlation between positive attitude changes and degree of open-mindedness (question #2).

Prior to the posttest, a multivariant discriminate analysis was used to divide the responses of the experimental group into four cells: (a) positive attitudes and open-minded, (b) positive attitudes and closed-minded, (c) negative attitudes and open-minded, and (d) negative attitudes and closed-mindedness.

A Pearson product moment coefficient was used to determine relationships between attitude changes and changes in degrees of open-mindedness (questions #3, 4, 5, and 6).

Bogut, Thomas L. "The Effects of Sequencing Selected Strategies on the Attitudes and Open-mindedness of Pre-service Elementary Science Teachers." Paper presented at the 48th annual meeting of the National Association for Research in Science Teaching Los Angeles, California, March, 1975. (ERIC Document Reproduction Service No. ED 108899)

Butzow, John W., Jr. "Why the New School Science Doesn't Sell." Science and Children, Volume 10, No. 5, 1973.

Piper, Martha K. "The Investigation of Attitude Changes of Elementary Preservice Teachers in a Competency-based, Field-oriented Science Methods Course and Attitude Changes of Classroom Teachers Cooperating with the Field Component." Paper presented at the 49th annual meeting of the National Association for Research in Science Teaching, Los Angeles, California, April, 1976. (Monograph to be published, ERIC-NIE, January, 1977)

Rokeach, Milton. The Open and Closed Mind. New York: Basic Books, 1960.

THE EFFECTS OF AN ELEMENTARY SCIENCE METHODS COURSE ON THE ATTITUDES OF PRESERVICE TEACHERS TOWARD SCIENCE AND SCIENCE TEACHING

Lowell J. Bethel
The University of Texas
Austin, Texas 78712

Martha Piper
University of Houston
Houston, Texas 77025

William G. Lamb
Delta State University
Cleveland, Mississippi 38733

Research in science education indicates that teachers' attitudes toward science influence the direction of the attitudes towards science developed by their pupils. For that reason, positive attitudes toward science by preservice elementary teachers should be a major objective of science methods courses. Attitudes toward science have at least identifiable components - a philosophical view of science as either tentative or absolute truths, and a negative or positive attitude toward science. However, not much research has been conducted in this area. Therefore, a study was conducted to evaluate science methods courses and their effects on students' attitudes and philosophical views of science.

Preservice elementary education majors (N = 117) participated in an elementary science methods course that stressed hands-on science activities and inquiry-oriented, problem-solving exercises. In addition, students designed science teaching aids and materials for science structure. The methods course was designed to explore the content, methodology, and the processes of inquiry that are employed in teaching elementary school science.

The Science Attitude Scale (SAS) was selected for the purpose of evaluating preservice elementary teachers' attitudes toward science and the teaching of science. Views of preservice elementary teachers towards science were assessed by the Views of Science Questionnaire (VS). Both instruments were administered at the beginning (pre-test) and at the conclusion of the course (post-test).

A preliminary evaluation of the effect on attitudes toward science of the treatment above was conducted using a pre-post no control group design. The same treatment was then evaluated for effects on philosophical view of science using a pre-post non-equivalent control group design.

Sixty-one students enrolled in an elective elementary science methods course were utilized in the study during the Fall of 1974. The SAS instrument was administered both at the beginning and at the conclusion of the semester. During the Spring of 1975, students enrolled in three treatment sections of science methods (N = 12, 21, and 23) and one control section of preservice teachers (N = 32) enrolled in a math methods course were administered the VS instrument at the beginning and at the conclusion of the courses.

Repeated measures ANOVA was used to compare pre- and post-test means from the SAS. ANCOVA was used to compare group means from the VS instrument.

Repeated measures ANOVA indicated that attitudes toward science and science teaching improved from pre- to post-assessment ($p = .0001$). ANVOCA indicated that the science methods course enhanced the view of science as a tentative enterprise compared to the math methods course ($p = .02$).

The science methods course appears to be successful in helping preservice elementary teachers to view science as tentative and to improve their attitudes toward science and teaching science. For these two affective objectives, the instructional model described is effective.

THE EFFECTS OF SCIENCE METHODS COURSE COMPONENTS ON ELEMENTARY EDUCATION MAJORS: REPLICATION AND EXTENSION

William G. Lamb
Delta State University
Cleveland, Mississippi 38733

Martha Piper
University of Houston
Houston, Texas 77025

Lowell J. Bethel
The University of Texas
Austin, Texas 78712

The importance of enhancing the attitudes of elementary education majors towards science and of helping them to view science as a tentative enterprise has been established in other papers in this set and will not be reiterated herein. That methods courses can effect those changes has also been demonstrated. Those courses are similar in many respects: using SAPA, SCIS and ESS materials; instructor modeling of desired teaching behaviors; using hands-on process skill and inquiry oriented activities; and having methods students use the NSF curriculum materials and/or self-designed materials for micro-teaching. It is unclear which components are responsible for the observed changes, however. This paper reports a comparison of two methods course structures and the attitude shifts associated with those different structures.

Design: Pre-post non-equivalent control group design.

Subjects: Ss included all students enrolled for the non-required science methods course each of two semesters during 1975-76 at a small southeastern University.

Treatment: First semester students (n = 8) received instruction essentially identical to that described in another paper in this set. The same course outline and requirements were used. Second semester students (n = 7) received a field-based course emphasizing teaching hands-on inquiry to full-size classes of elementary children using readily available materials. The amount of time spent by methods students in conducting their own investigations was significantly lower during the second semester.

Instrumentation: As in another study in this set, attitudes toward science and teaching science were measured with the Science Attitude Scale and views of science were measured with the Views of Science questionnaire, with both administered as pre and post tests during the first and last meetings of each semester.

Analysis: ANCOVA based on total scores of each S, pre and post, was conducted to compare approaches. Repeated measures ANOVA was used to compare changes from pre to post.

ANCOVA indicated that the second semester Ss increased slightly but not significantly more in attitudes toward science and science teaching ($p = 0.17$) compared to first semester Ss. The reverse relationship was observed with view of science, this difference being significant ($p = 0.06$). ANOVA indicated both groups significantly enhanced their attitudes toward science and science teaching from pre to post, but only the first semester Ss became more tentative in their view of science. It appears that a few investigations and experiences with teaching are sufficient for increasing attitudes toward science and science teaching but that changes in the philosophical view of science require significantly greater numbers of hands-on investigations for the methods students; i.e., helping children to have such experiences is apparently not as helpful as having them oneself.

The Ss described in the above study are currently being observed during their first year as inservice teachers so that the significance of attitudes and views held upon exit from a methods course can be determined, Without that information, one must conclude that more emphasis should be placed on investigations by methods students and less on field experiences if attitude changes are the only criteria being considered.

GENERAL SESSION II

Presiding: Roger G. Olstad, University of Washington, Seattle, Washington 98195.

Speaker: Mary Budd Rowe, University of Florida, Gainesville, Florida 32611.

"Science and Fate Control"

CONCURRENT SESSIONS VIII

Session VIIIA - Teacher Education

Presiding: Ellen S. Simmons, Columbia University, New York, New York 10027.

1. "Relationships Between Science Teacher Needs and Selected Teacher Variables." Kenneth D. Moore, The University of Tulsa, Tulsa, Oklahoma 74104.

2. "Needed Secondary School Science Teacher Attributes: A Synthesis from the Views of Science Teachers, Science Supervisors, and Science Educators." Eugene Chiappetta, University of Houston, Houston, Texas 77004 and Alfred Collette, Syracuse University, Syracuse, New York 13210.

3. "Attitude Changes of Teachers Trained and Selected as Model Science Teachers." Dorothy L. Gabel, Indiana University, Bloomington, Indiana 47401.

4. "The Effects of Studying a Question Classification System on the Cognitive Level of Preservice Teachers' Questions." Joseph P. Riley, University of Georgia, Athens, Georgia 30602.

5. "Estimation of the Reliability and Validity of Rating Science Teacher Behaviors." Masood S. Ashrafi and John T. Wilson, The University of Iowa, Iowa City, Iowa 52242.

RELATIONSHIPS BETWEEN SCIENCE TEACHER NEEDS AND SELECTED TEACHER VARIABLES

Kenneth D. Moore
The University of Tulsa
Tulsa, Oklahoma 74104

Too often science inservice programs are based on superficial surveys of science teacher interest. These interests are then interpreted to reflect the high priority needs of science teachers. Even when these interests do reflect the high priority needs of science teachers, individual teacher differences are ignored. These past failures of science inservice programs suggest that attention be directed toward the identification of the high priority perceived needs of science teachers as well as their relationship to certain teacher variables.

The purposes of this study were two-fold: first, to identify the high priority perceived science needs of elementary, junior high, and senior high science teachers; and, second, to determine whether there is a significant relationship between the perceived needs of science teachers and selected teacher variables.

The sample in this study consisted of 283 science teachers as represented by the returns received in a previous study designed to identify the needs of science teachers. These teachers were randomly selected from the 21 school districts of a county whose population of 2,100,000 people represents a broad spectrum of socioeconomic levels ranging from rural agriculture to metropolitan city. The three strata samples were 102 elementary teachers, 88 junior high science teachers, and 93 senior high science teachers.

The teachers in the sample were classified as to school level, experience, grade level, and science discipline. The statistical technique used to test for significant differences in group needs was the factorial analysis of variance with approximations for unequal numbers of subjects per group.

The data in this study were the teacher responses to the Moore Assessment Profile (MAP). Only responses to those items which had a loading greater than .450 on each of the 18 factor needs identified in a prior study were analyzed. The high loading item responses were measured in terms of a weighted value, one through four, which corresponded to the four columns on the assessment profile.

The results of the analysis suggest that the high priority factor needs of all science teachers were: (1) help in developing basic scientific reasoning skills in students; (2) help in motivating students to learn; (3) help in guiding students to set up and achieve realistic goals; (4) training in the effective classroom use of innovative teaching techniques; and (5) help in

providing realistic science experiences. The analysis also indicated that a statistically significant relationship ($p < .05$) existed between the intensity of need on several identified factor needs and specific teacher variables. Those teacher variables which were significantly related to the intensity of need of several identified factor needs were school level, experience, grade level, and science discipline.

In general, the findings indicate that science teachers have certain needs which are common to all science teachers. In addition, the findings suggest that certain needs are shared only by specific groups of science teachers.

NEEDED SECONDARY SCHOOL SCIENCE TEACHER ATTRIBUTES: A SYNTHESIS FROM THE VIEWS OF SCIENCE TEACHERS, SCIENCE SUPERVISORS, AND SCIENCE EDUCATORS

Eugene L. Chiappetta
University of Houston
Houston, Texas 77004

and

Alfred T. Collette
Syracuse University
Syracuse, New York 13210

Competency Based Teacher Education (CBTE) has brought renewed interest in research on teacher effectiveness. One of its foci has been to identify teacher attributes that positively affect student learning. Science educators are participating in the CBTE movement; some are attempting to identify science teacher competencies. The purpose for the present study was to determine competencies for secondary school science teachers through the perceptions of science teachers, science supervisors, and science educators.

The research methodology employed a three-round Delphi procedure which was conducted in an identical manner, but carried out separately with three different populations. The representative populations for the science teachers, science supervisors, and science educators were the New York State Science Teachers, members of the National Science Supervisors Association, and members of the National Association for Research in Science Teaching respectively.

In round one a random sample of 100 subjects in each group was asked to list those competencies that all secondary science teachers should possess (grades 7-12). A panel of five judges analyzed and sorted the responses into common categories. This resulted in classifications of cognitive competencies, affective competencies, and personality characteristics.

The cognitive competencies went into the construction of the round two instrument which was mailed to a random sample of 100 subjects in each group. The subjects were asked to identify at what level on Bloom's Taxonomy of Cognitive Objectives they felt teachers should demonstrate a given competency.

In round three the cognitive competencies with their respective behavioral indicators were mailed to a random sample of 100 subjects in each group. They were instructed to rank the competencies in order of their importance.

The results of the research produced with each group: 15 cognitive competencies with behavioral indicators, a few affective competencies, and several personality characteristics. These sets of teacher attributes were analyzed for commonality. This resulted in the identification of 13 cognitive competencies, two affective competencies, and 5 personality characteristics that appear to be needed attributes by secondary school science teachers.

The competencies and personality characteristics synthesized from the research can provide science educators with a set of dimensions and indicators to train and select secondary school science teachers. In addition, these teacher attributes can be further validated in terms of student achievement and attitude toward science.

ATTITUDE CHANGES OF TEACHERS TRAINED AND SELECTED AS MODEL SCIENCE TEACHERS

Dorothy L. Gabel
Indiana University
Bloomington, Indiana 47401

The development of positive attitudes toward science and science teaching in preservice and inservice teachers is a recognized goal of science education. Modification of science courses and science methods courses has brought about changes in attitudes of preservice teachers. Less research has been conducted with inservice teachers although there has been some attempt to effect change through workshops.

The purpose of this study was to determine if elementary teachers' attitudes toward science and science teaching would become more positive if

1. they participated in a four week workshop on the new science curricula.

2. the training they received was directed toward ESS, SCIS or SAPA.

3. they served as model science teachers for preservice teachers who observed and taught in their classrooms.

Thirty-six teachers who attended a four week workshop on the new science curricula participated in the study. Teachers selected the science curriculum that they wished to study after an overview on all projects and a survey of materials available in their schools. Twenty teachers were selected as model teachers on the basis of proximity of their schools to the university. Pre-service teachers were placed in 11 teachers' classrooms.

A correlated t-test was used to analyze pre postworkshop changes in attitude toward science and science teaching as measured by Moore's Attitude Scales. A significant ($p < 0.05$) positive change in attitude toward teaching science but not toward science resulted from the workshop.

A 2 x 3 analysis of variance (2 levels of model teachers - with and without observers and three levels of training - ESS, SCIS and SAPA) was used to determine the effect of the type of training on attitudes. No significant differences were found for the type of training received nor for the type of model teacher the workshop participant would become.

Data collected after preservice teachers observed and taught in the model teacher's classroom were also analyzed using a 2 x 3 analysis of variance. Although there were no significant changes

in the total attitude scores on the teaching of science and science, there was a positive gain ($p < 0.05$) on a subscale of the teaching attitude scale for teachers with observers.

Results of this experiment confirm previous experiments that indicate teachers' attitudes can be changed by attending workshops on the new science curricula. They also indicate that it may be possible to change attitudes by having teachers act as models for preservice teachers.

THE EFFECTS OF STUDYING A QUESTION CLASSIFICATION SYSTEM ON THE COGNITIVE LEVEL OF PRESERVICE TEACHERS' QUESTIONS

Joseph P. Riley
University of Georgia
Athens, Georgia 30602

One method of improving the cognitive level of teachers' questions appears to be the study of a question classification system. The basis for this observation rests chiefly on the research findings of Farley and Clegg (1969) who found that six elementary student teachers trained in the Bloom Taxonomy (1956) achieved higher cognitive level behavior during social studies instruction than did a control group.

Using a larger sample and focusing on science education, this study investigated the question: Does the study of a question classification system result in a change in the cognitive level of questions asked by preservice teachers? A second area of inquiry was to determine the effects of teaching in two different science programs on teacher questioning strategies.

Forty preservice elementary teachers were randomly assigned to treatments and teaching roles in two science programs. The two levels of treatment were:

Level A -- This group received three and one-half hours of instruction in classifying questions. Training consisted of studying a question category system and then using this system to classify questions as Cognitive Memory, Convergent Thinking, Evaluative Thinking or Non-Thinking. The Handbook of Effective Questioning Techniques (Blosser, 1973) was the basic source of study.

Level B control -- This group received no training in classifying questions. The two science programs were:

1. Science - A Process Approach
2. Concepts in Science - a science text

Figure 1 illustrates the 2 x 2 factorial design.

	Question Training	No Training
SAPA		
CIS		

Figure 1. Experimental Design

After training in the analysis of questions, the students were administered a criterion measure to determine their ability to recognize different cognitive levels of questioning. A second measure was taken on audiotaped science lessons and analyzed to determine the cognitive level of the preservice teachers' questions.

Significant differences were found between the treatment and control on both dependent variables. The students receiving training scored higher than the control in their ability to correctly classify questions and in their use of higher cognitive level questions in their classrooms. Also, preservice teachers using the Science - A Process Approach program scored significantly higher than those in the Concepts in Science Program on the cognitive level rating of their questions. An interesting finding is that, although S-APA teachers asked high level questions, they asked significantly fewer questions than did teachers using the Concepts in Science program.

This study empirically supports the position that given training in the knowledge and use of a question categorizing system, preservice teachers will improve the cognitive emphasis of their questions. It also provides evidence that involvement in a particular science curriculum can make a difference in the number and type of questions teachers ask.

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ESTIMATION OF THE RELIABILITY AND VALIDITY OF RATING SCIENCE TEACHER BEHAVIOR

Masood S. Ashrafi

and

John T. Wilson
The University of Iowa
Iowa City, Iowa 52242

The problem of estimating the reliability for ratings is neither new nor unsolvable. As early as 1940 different approaches had been suggested and, over the past three decades, the solutions to the problem have gradually matured and by 1972 a useful and general treatment could be found.

Many have used raters' agreement coefficients (or percents) as the estimate of reliability of the measure. Others have utilized ANOVA procedures to calculate error terms for individual and average ratings. However, none have adequately dealt with the problem of estimating and interpreting the relevant reliability coefficients (there are many to be considered) as well as validity coefficients for ratings of teacher behaviors in the classroom.

The purpose of this paper, therefore, is:

1. to summarize the literature on this topic and hence discuss the difficulties encountered in the estimation of reliability and validity coefficients of performance measures in general and analyzing teacher behaviors from their audiotapes in particular,

2. discuss the use of ANOVA for obtaining many different reliability coefficients (including observers' agreement coefficients) while interpreting the meaning associated with each coefficient,

3. estimating the validity of rating by treating teacher behaviors similar to the performance on an essay test,[1]

4. applying the theoretical formulas obtained by the above mentioned methods to the data sampled from 600 audiotapes of science teachers.

ANOVA techniques have been used on a four-dimensional design for analyzing science teacher behaviors. The dimensions consisted of variations among teachers (T), variations among raters (J for

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[1]Coffman, W. E. "On The Validity of Essay Tests of Achievement." Journal of Educational Measurement, 3, 1966.

Judges), variations of behaviors on different situations or categories (S) and finally one added dimension of variations among different samples or on different occasions (O for occasions). Using this model the total score variance may be expressed as:

$$\sigma^2_x = \sigma^2_T + \sigma^2_S + \sigma^2_{TS} + \sigma^2_e$$

Where σ^2_e is the error variance which in turn may be written as:

$$\sigma^2_e = \sigma^2_O + \sigma^2_J + \sigma^2_{TJ} + \sigma^2_{SJ} + \sigma^2_{TSJ} + \sigma^2_{OJ} + \sigma^2_E$$

As can be seen σ^2_x includes the interaction of T x S and σ^2_e includes different interaction terms of T x J, S x J, O x J, T x S x J.

The reliability coefficient is defined as:

$$r = \frac{\sigma^2_{error}}{\sigma^2_{observed}}$$

using different σ^2_{error} and $\sigma^2_{observed}$ one may calculate a number of coefficients each having different interpretations.

About 600 audiotapes were collected from science teachers of different grades and different curricula. One hundred tapes were randomly selected from this population. Two separate five-minute sections of each sample tape were chosen to be rated separately by three trained judges. This part of the data collection procedure is both new and effective as well as justifiable. Five minutes is sufficient for allowing a variety of behaviors to occur. Also it is short enough for practical purposes of rating. Two different samples of the same tape provide a source of variation over occasions and yield more reliable and meaningful data. The categories of teaching skills included reinforcement, silence, probing, assessing knowledge, observing, classifying, inferring, predicting, clarifying definitions, recognizing assumptions, identifying conclusions, symbolic coding, simplifications, defining relationships, planning procedures, record keeping, giving information, unclear question and other behaviors.

Much research has been going on in the area of science teacher behavior in the classroom. The majority of such research studied suffers from two major weak points. First, the reliability and validity estimations are either non-existent or very inadequate. Second, the categories used in different instruments are both vague and irrelevant to science.

This study deals elaborately with reliability and validity issues. Besides, the categories used in our instrument are not only clear and specific but relevant to science teaching.

CONCURRENT SESSIONS VIII

Session VIIIB - JRST Editorial Board Meeting

Presiding: David P. Butts, University of Georgia, Athens, Georgia 30602.